Allen-Bradley

Medium Voltage SMC-Flex™ Motor Controller

Bulletins 1503E, 1560E and 1562E

User Manual
for Series K

Rockwell Automation

Important User Information

Solid state equipment has operational characteristics differing from those of electro-mechanical equipment. Safety Guidelines for the Application, Installation and Maintenance of Solid State Controls (Publication SGI-1.1 available from your local Rockwell Automation sales office or online at http://www.ab.com/manuals/gi) describes some important differences between solid state equipment and hard-wired electromechanical devices. Because of this difference, and also because of the wide variety of uses for solid state equipment, all persons responsible for applying this equipment must satisfy themselves that each intended application of this equipment is acceptable.

In no event will Rockwell Automation, Inc. be responsible or liable for indirect or consequential damages resulting from the use or application of this equipment.

The examples and diagrams in this manual are included solely for illustrative purposes. Because of the many variables and requirements associated with any particular installation, Rockwell Automation, Inc. cannot assume responsibility or liability for actual use based on the examples and diagrams.

No patent liability is assumed by Rockwell Automation, Inc. with respect to use of information, circuits, equipment, or software described in this manual.

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Throughout this manual we use notes to make you aware of safety considerations.

WARNING	Identifies information about practices or circumstances that can cause an explosion in a hazardous environment, which may lead to personal injury or death, property damage, or economic loss.
IMPORTANT	Identifies information that is critical for successful application and understanding of the product.
ATTENTION	Identifies information about practices or circumstances that can lead to personal injury or death, property damage, or economic loss. Attentions help you: • identify a hazard • avoid a hazard • recognize the consequence
SHOCK HAZARD	Labels may be located on or inside the equipment to alert people that dangerous voltage may be present.
BURN HAZARD	Labels may be located on or inside the equipment to alert people that surfaces may be dangerous temperatures.

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Installation (cont.)

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Service Procedure

For your convenience, the Rockwell Automation Global Manufacturing Solutions (GMS), provides an efficient and convenient method of servicing medium voltage products.

Contact your local area support office to make arrangements to have a qualified service representative come to your facility.

A complete listing of Area Support Offices may be obtained by calling your local Rockwell Automation Distributor or Sales Office.

For MV SMC-Flex technical support on start-up or existing installations, contact your Rockwell Automation representative. You can also call **1-519-740-4790** for assistance Monday through Friday from 9:00 a.m. to 5:00 p.m. (Eastern time zone).

Product Overview

Manual Objectives

This manual is intended for use by personnel familiar with Medium Voltage and solid-state power equipment. The manual contains material which will allow the user to operate, maintain and troubleshoot the MV SMC-Flex™ family of controllers. The family consists of the following Bulletin numbers: 1503E, 1560E and 1562E.

Note: This user manual pertains to units with Series letter K or later, and firmware release 4.xxx (or later).

Documentation

The following Rockwell Automation publications provide pertinent information for the MV SMC-Flex and components:

- MVB-5.0 — General Handling Procedures for MV Controllers
- 1500-UM055B-EN-P — Medium Voltage Controller Two-High Cabinet (200A/400A) – User Manual
- 1502-UM050C-EN-P — 400A Vacuum Contactor, Series D – User Manual
- 1502-UM052B-EN-P — 400A Vacuum Contactor, Series E – User Manual
- 1502-UM051C-EN-P — 800A Vacuum Contactor, Series D and E – User Manual
- 1560E-SR022B-EN-P — Medium Voltage SMC-Flex Controllers – General Specifications
- 1503-UM051B-EN-P — IntelliVAC Contactor Control Module

Description

The MV SMC-Flex is a solid-state, three-phase, AC line controller. It is designed to provide microprocessor-controlled starting and stopping of standard three-phase, squirrel-cage induction motors, using the same control module as the Allen-Bradley Bulletin 150 SMC-Flex.

1503E – OEM Controller

A chassis-mount medium voltage solid-state controller designed to mount in an OEM or customer supplied structure, and designed to work in conjunction with an existing or OEM/customer supplied starter. It is comprised of several modular components, including:

- Frame-mounted or loose power stacks including gate driver boards
- Loose interface and voltage feedback boards
- Fiber optic cables for SCR firing
- Microprocessor based control module
- Bypass vacuum contactor

Description (cont.)

1560E – Retrofit Controller

A medium voltage solid-state controller designed to work in conjunction with an existing customer-supplied starter. It includes:

- Tin-plated, copper, horizontal power bus (optional)
- A continuous, bare copper ground bus
- Power electronics
- A bypass vacuum contactor
- Three (3) current transformers
- A low voltage control panel complete with microprocessor-based control module
- Top and bottom plates to accommodate power cables.

Note: See Interlocking, page 2-12.

1562E – Combination Controller

A medium voltage solid-state controller that provides isolation and protection for new installations. It includes:

- Tin-plated, copper, horizontal power bus (optional)
- A continuous, bare copper ground bus
- Power electronics
- A main non-load-break isolating switch and operating handle
- An isolation vacuum contactor
- A bypass vacuum contactor
- Three (3) current limiting power fuses for NEMA Class E2 operation
- Three (3) current transformers
- A control power transformer (optional)
- A low voltage control panel complete with microprocessor-based control module
- Space for necessary auxiliary control and metering devices
- Top and bottom plates to accommodate power cables
- Motor overload protection (included in SMC-Flex control module)

SMC-Flex™ Control Module

The MV SMC-Flex controller offers a full range of starting and stopping modes as standard:

- Soft Start with Selectable Kickstart
- Soft Stop
- Current Limit Start with Selectable Kickstart
- Linear Acceleration with Selectable Kickstart
- Linear Deceleration
- Dual Ramp Start
- Preset Slow Speed ❶
- Full Voltage Start

❶ This option utilizes gating patterns which result in motor and line currents that produce noise and vibration in the motor and/or distribution transformer. This must be considered before applying this option.

SMC-Flex™ Control Module (cont.)

Other features that offer further user benefit include:
- Extensive protection features
- Metering
- Communication capability
- I/O

Innovative control option provides enhanced performance:
- Pump Control (Start and Stop Control modes)

These modes, features and options are further described in this chapter.

Starting Modes

Soft Start

This mode has the most general application. The motor is given an initial torque setting, which is user-adjustable from 0 to 90% of locked-rotor torque. From the initial torque level, the output voltage to the motor is steplessly increased during the acceleration ramp time. The acceleration ramp time is user-adjustable from 0 to 30 seconds. Once the MV SMC-Flex controller senses that the motor has reached the up-to-speed condition during the voltage ramp operation, the output voltage automatically switches to full voltage, and the bypass contactor is closed.

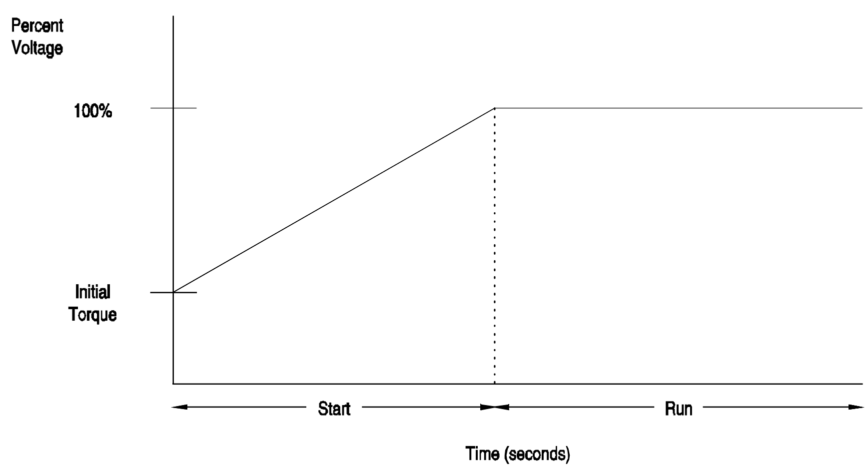


Figure 1.1– Soft Start

Starting Modes (cont.)

Selectable Kickstart ❶

Selectable kickstart provides a power boost at start-up that is user-adjustable from 0 to 90% of locked rotor torque. The additional power helps motors generate higher torque to overcome the resistive mechanical forces of some applications when they are started. The selectable kickstart time is user-adjustable from 0.0 to 2.0 seconds.

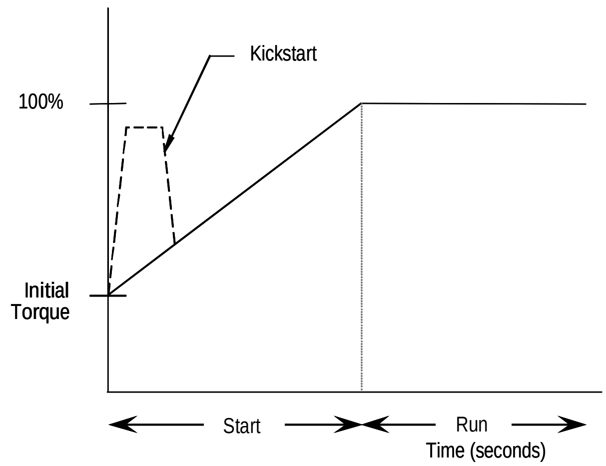


Figure 1.2 – Selectable Kickstart

Current Limit Start ❶

This starting mode provides a true current limit start that is used when limiting the maximum starting current is necessary. The Current Limit level is user-adjustable from 50% to 600% of the motor's full-load ampere rating, and the current limit time is user-adjustable from 0 to 30 seconds. Once the MV SMC-Flex™ controller senses that the motor has reached the up-to-speed condition during the current limit starting mode, the output voltage automatically switches to full voltage and the bypass contactor is closed.

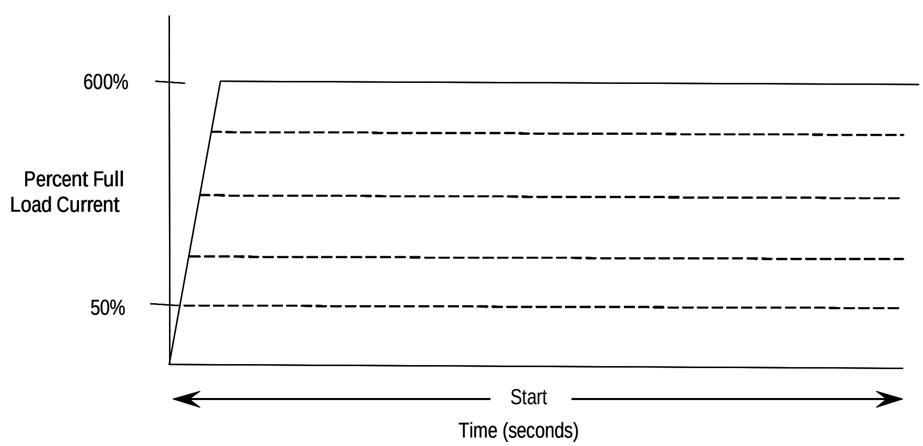


Figure 1.3 – Current Limit Start

❶ Kickstart is also available with Current Limit Start, Dual Ramp Start and Linear Acceleration.

Dual Ramp Start ❶

This starting mode is useful for applications that have varying loads (and therefore varying starting torque requirements). Dual Ramp Start allows the user to select between two separate Soft Start profiles with separately adjustable ramp times and initial torque settings.

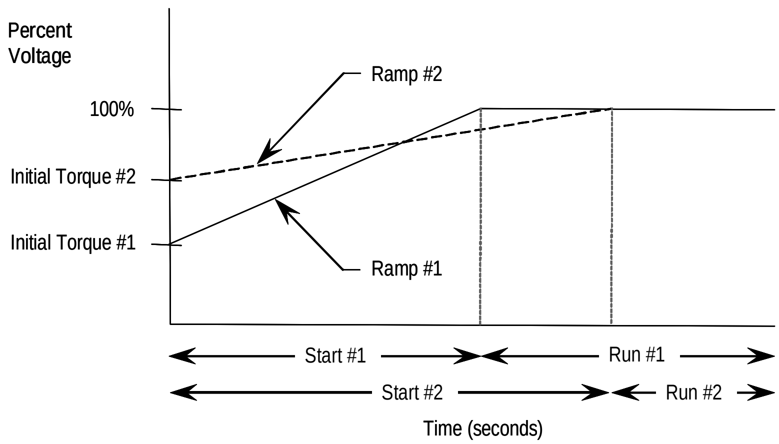


Figure 1.4 – Dual Ramp Start

❶ Dual Ramp Start is available only with the standard controller.

Full Voltage Start

This starting mode is used for applications requiring across-the-line starting. The output voltage to the motor will reach full voltage within ¼ second.

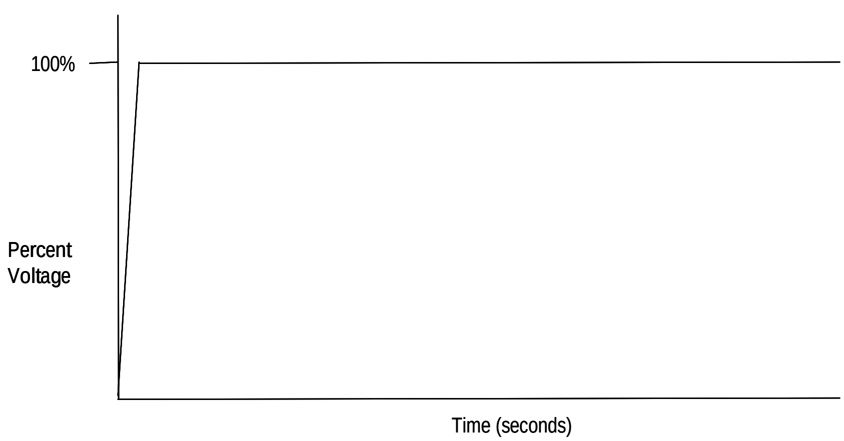


Figure 1.5 – Full Voltage Start

Starting Modes (cont.)

Preset Slow Speed

This option can be used in applications that require a slow-speed jog for general purpose positioning. Preset Slow Speed provides either 7% of base speed (low) or 15% of base speed (high) settings in the forward direction. Reverse can also be programmed and offers 10% of base speed (low) and 20% of base speed (high) settings.

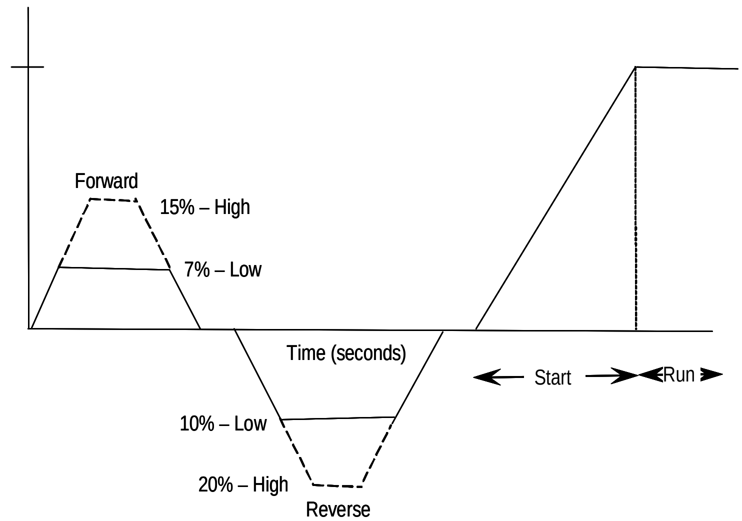


Figure 1.6 – Preset Slow Speed Option

Important: Slow speed running is not intended for continuous operation due to reduced motor cooling. The two starts per hour limitation also applies to slow speed operation. This option employs a cycle-skipping scheme which produces limited torque. Applications should be checked with the factory.

Linear Speed Acceleration and Deceleration

The SMC-Flex has the ability to control the motor speed during starting and stopping maneuvers. A tachometer signal (0 to 5V DC) is required to perform this start mode. The start time is selectable from 0 to 30 seconds and determines the time the motor will ramp from 0 speed to full speed. Kickstart is available with this option.

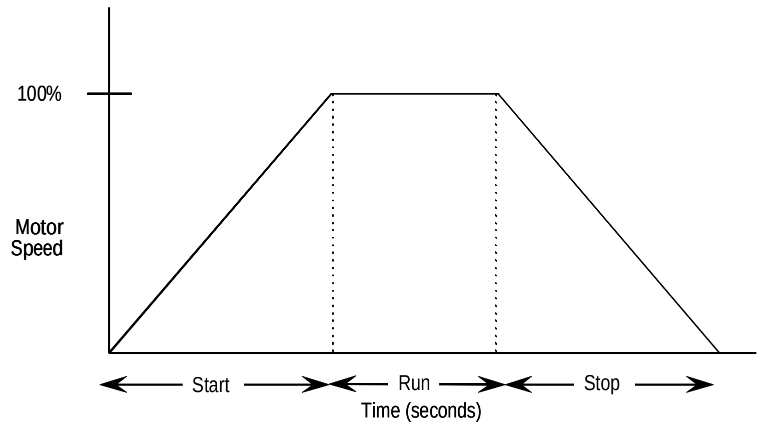


Figure 1.7 – Linear Speed Acceleration

Linear deceleration does not need to be used, even if linear acceleration is used. The stop time can be programmed for 0 to 120 seconds. Linear deceleration cannot brake the motor/load and reduce the stop time.

Note: Consult factory if settings over 30 seconds are required. The base rating of the MV SMC-Flex is two starts (or one start/stop combination) per hour, thirty seconds maximum for each operation. A stopping operation counts as a start for purposes of thermal capacity calculations.

ATTENTION

Linear Deceleration is not intended to be used as an emergency stop. Such usage may result in severe injury or death. Refer to the applicable standards for emergency stop requirements.

Starting Modes (cont.)

Soft Stop

This feature can be used in applications that require an extended coast-to-rest time. The voltage ramp-down time is user-adjustable from 0 to 120 seconds and is adjusted independently from the starting time. The load will stop when the output voltage drops to a point where the load torque is greater than the developed motor torque.

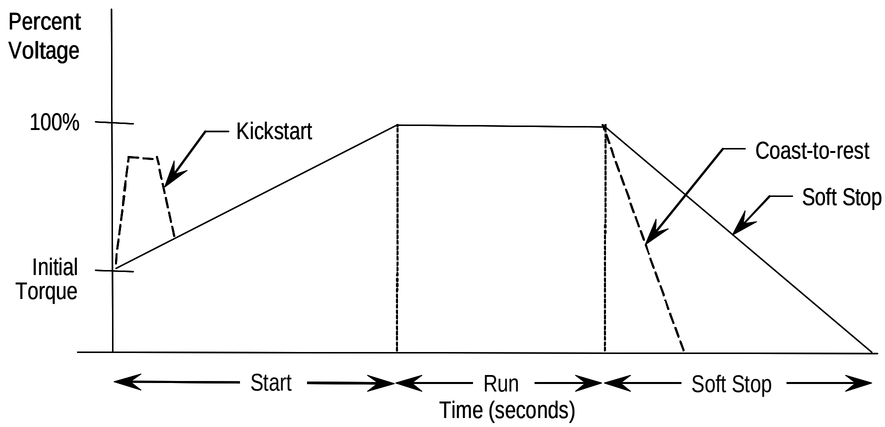


Figure 1.8 – Soft Stop Option

Note: Consult factory if settings over 30 seconds are required. The base rating of the MV SMC-Flex is two starts (or one start/stop combination) per hour, thirty seconds maximum for each operation. A stopping operation counts as a start for purposes of thermal capacity calculations.

ATTENTION

Soft Stop is not intended to be used as an emergency stop. Such usage may result in severe injury or death. Refer to the applicable standards for emergency stop requirements.

Protection and Diagnostics

The MV SMC-Flex™ controller is capable of providing the following protective and diagnostic features:

Overload

The MV SMC-Flex controller meets applicable requirements as a motor overload protection device. Thermal memory provides added protection and is maintained even when control power is removed. The built-in overload algorithm controls the value stored in Parameter 12, Motor Thermal Usage (see Chapter 4, Programming). An Overload Fault will occur when this value reaches 100%. The parameters below provide application flexibility and easy setup.

Parameter	Range
Overload Class	Disable, 10, 15, 20, 30
Overload Reset	Manual – Auto
Motor FLC	1.0 – 2200 amps
Service Factor	0.01 – 1.99

Important: During slow speed operations, current waveforms exhibit non-sinusoidal characteristics. These non-sinusoidal characteristics inhibit the controller's current-measurement capability. To compensate for additional motor heating that may result, the controller uses motor thermal modeling, which increments motor thermal usage. This compensation takes place when the Preset Slow Speed option is used.

Notes:

1. If the MV SMC-Flex is used to control a multi-speed motor, or more than one motor, the Overload Class parameter must be programmed to "OFF" and separate overload relays must be supplied for each speed/motor.
2. Automatic reset of an overload fault requires the start input to be cycled in a 2-wire control scheme.
3. The trip rating is 117% of the programmed FLC.

Figures 1.9 and 1.10 provide the overload trip curves for the available trip classes.

Protection and Diagnostics (cont.)

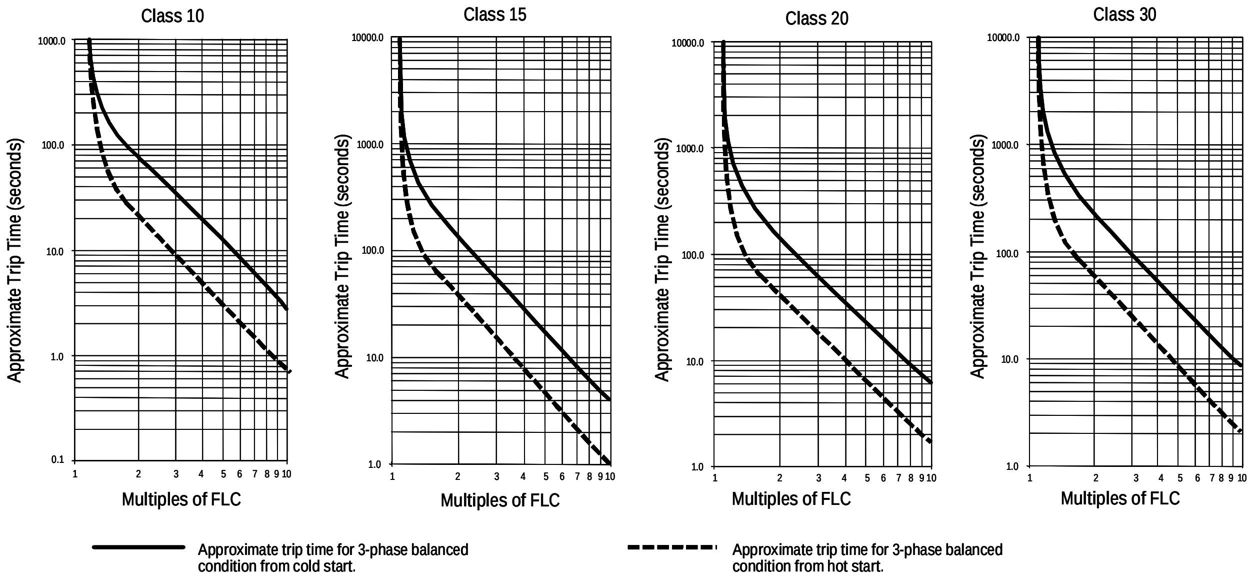


Figure 1.9 – Overload Trip Curves

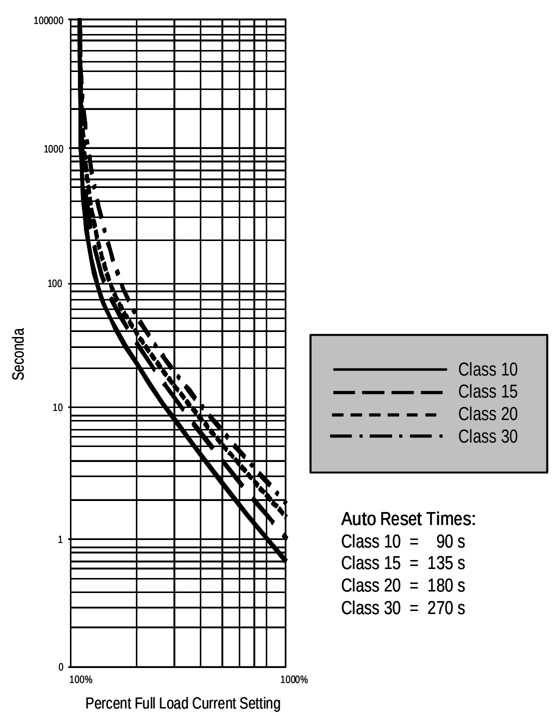


Figure 1.10 – Restart Trip Curves after Auto Reset

Underload ❶

Utilizing the underload protection of the MV SMC-Flex controller, motor operation can be halted if a sudden drop in current is sensed.

The MV SMC-Flex controller provides an adjustable underload trip setting from 0 to 99% of the programmed motor full load current rating. Trip delay time can be adjusted from 0 to 99 seconds.

❶ Underload protection is disabled during slow speed and braking operations.

Undervoltage ❷

Utilizing the undervoltage protection of the MV SMC-Flex, motor operation can be halted if a sudden drop in voltage is detected.

The MV SMC-Flex controller provides an adjustable undervoltage trip setting from 0 to 99% of the programmed motor voltage. Trip delay time can be adjusted from 0 to 99 seconds.

Note: For medium voltage applications, undervoltage protection should be set from 80 to 99%.

An alarm (pre-fault) indication level can be programmed to indicate the unit is getting close to faulting. The alarm modification information is displayed through the LCD, HIM, Communication (if applicable) and alarm contact closing.

Overvoltage ❷

Utilizing the overvoltage protection of the MV SMC-Flex, motor operation can be halted if a sudden increase in voltage is detected.

The MV SMC-Flex controller provides an adjustable overvoltage trip setting from 0 to 199% of the programmed motor voltage. Trip delay time can be adjusted from 0 to 99 seconds.

Note: For medium voltage applications, overvoltage protection should be set from 100 to 115%.

An alarm (pre-fault) indication level can be programmed to indicate the unit is getting close to faulting. The alarm modification information is displayed through the LCD, HIM, Communication (if applicable) and alarm contact closing.

❷ Undervoltage, overvoltage, and voltage unbalance protection are disabled during braking operation.

Protection and Diagnostics (cont.)

Unbalance ❶

The MV SMC-Flex is able to detect an unbalance in line voltages. Motor operation can be halted if the unbalance is greater than the desired range.

The MV SMC-Flex controller provides an adjustable unbalance setting from 0 to 25% of the line voltages. Trip delay time can be adjusted from 0 to 99 seconds.

An alarm (pre-fault) indication level can be programmed to indicate the unit is getting close to faulting. The alarm modification information is displayed through the LCD, HIM, Communication (if applicable) and alarm contact closing.

❶ Undervoltage, overvoltage, and voltage unbalance protection are disabled during braking operation.

Stall Protection and Jam Detection

The MV SMC-Flex controller provides both stall protection and jam detection for enhanced motor and system protection.

- Stall protection is user-adjustable from 0.0 to 10.0 seconds (enabled only after the programmed start time expires).
- An alarm (pre-fault) indication level can be programmed to indicate the unit is getting close to faulting. The alarm modification information is displayed through the LCD, HIM, Communication (if applicable) and alarm contact closing.
- Jam detection allows the user to determine the jam level (up to 1000% of the motor's full-load current rating) and the delay time (up to 99.0 seconds) for application flexibility.

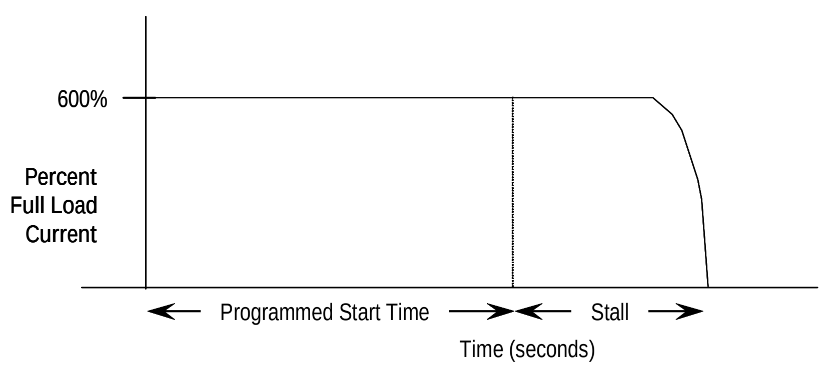


Figure 1.11 – Stall Protection

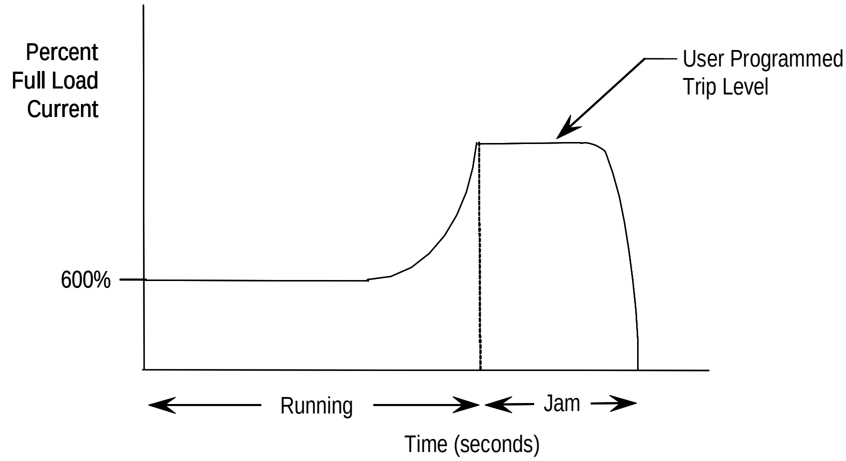


Figure 1.12 – Jam Detection ❶

❶ Jam Detection is disabled during slow speed and braking operation.

Ground Fault

In isolated or high impedance-grounded systems, core-balanced current sensors are typically used to detect low level ground faults caused by insulation breakdowns or entry of foreign objects. Detection of such ground faults can be used to interrupt the system to prevent further damage, or to alert the appropriate personnel to perform timely maintenance.

The MV SMC-Flex's ground fault detection capabilities consist of using a core balance current transformer for 1 to 5A core-balanced ground fault protection with the option of enabling Ground Fault Trip, Ground Fault Alarm, or both (a core balance CT can be provided with 1562E units).

Ground Fault Trip

The MV SMC-Flex will trip with a ground fault indication if:

- No trip currently exists
- Ground fault protection is enabled
- *GF Inhibit Time* has expired
- *GF Current* is equal to or greater than the *GF Trip Level* for a time period greater than the *GF Trip Delay*

Parameter 75, *Gnd Flt Inh Time*, allows the installer to inhibit a ground fault trip from occurring during the motor starting sequence and is adjustable from 0 to 250 seconds.

Protection and Diagnostics (cont.)

Ground Fault Trip (cont.)

Parameter 74, *Gnd Flt Delay,* allows the installer to define the time period a ground fault condition must be present before a trip occurs. It is adjustable from 0.1 to 25 seconds.

Parameter 73, *Gnd Flt Level,* allows the installer to define the ground fault current at which the MV SMC-Flex will trip. It is adjustable from 1.0 to 5.0 A.

Important: The ground fault inhibit timer starts after the maximum phase of load current transitions from 0 A to 30% of the device's minimum *FLA Setting* or the *GF Current* is greater than or equal to 0.5 A. The MV SMC-Flex does not begin monitoring for a ground fault condition until the *Gnd Flt Inh Time* expires.

Ground Fault Alarm

The MV SMC-Flex will indicate a Ground Fault Alarm if:

- No warning currently exists
- Ground fault alarm is enabled
- *GF Inhibit Time* has expired
- *GF Current* is equal to or greater than the *Gnd Flt A Lvl*

Parameter 77, *Gnd Flt A Lvl*, allows the installer to define the ground fault current at which an alarm will be indicated. It is adjustable from 1.0 to 5.0 A.

Parameter 78, *Gnd Flt A Dly*, allows the installer to define the time period a ground fault alarm condition must be present before a trip occurs. It is adjustable from 0.1 to 25 seconds.

Thermistor/PTC Protection

The MV SMC-Flex provides terminals 23 and 24 for the connection of positive temperature coefficient (PTC) thermistor sensors. PTC sensors are commonly embedded in motor stator windings to monitor the motor winding temperature. When the motor winding temperature reaches the PTC sensor's temperature rating, the PTC sensor's resistance transitions from a low to high value. Since PTC sensors react to actual temperature, enhanced motor protection can be provided to address such conditions as obstructed cooling and high ambient temperatures.

The following table defines the MV SMC-Flex PTC thermistor input and response ratings:

Table 1.A – PTC Input Ratings

Response Resistance	3400 Ω ± 150 Ω
Reset Resistance	1600 Ω ± 100 Ω
Short-circuit Trip Resistance	25 Ω ± 10 Ω
Maximum Voltage at PTC Terminals (R_{PTC} = 4 kΩ)	< 7.5 V
Maximum Voltage at PTC Terminals (R_{PTC} = open)	30 V
Maximum Number of Sensors	6
Maximum Cold Resistance of PTC Sensor Chain	1500 Ω
Response Time	800 ms

The following figure illustrates the required PTC sensor characteristics, per IEC-34-11-2.

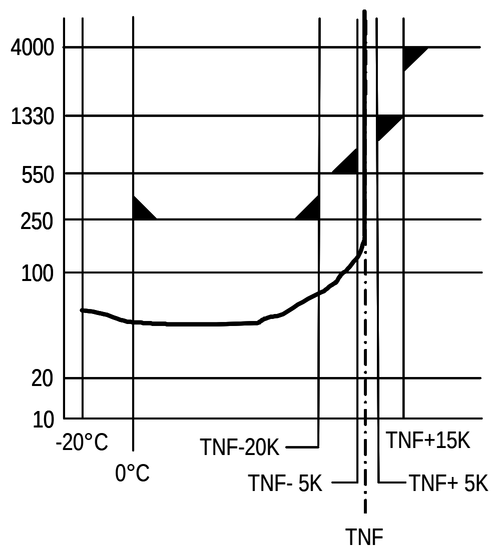


Figure 1.13 – PTC Sensor Characteristics per IEC-34-11-2

PTC Trip

The MV SMC-Flex will trip with a PTC indication if:

- No other fault currently exists
- PTC protection is enabled
- The resistance across terminals 23 and 24 is either greater than the relay's response resistance or less than the short-circuit trip resistance.

Protection and Diagnostics (cont.)

Open Gate

An open-gate fault indicates that improper SCR firing, typically caused by an open SCR gate or driver system, has been detected on one of the power poles. Before the controller shuts down, it will attempt to start the motor a total of three times (or as programmed in Parameter 82).

An open gate is detected when the module sends a gate signal to the SCRs but does not detect that they turned on. SCR turn-on is detected when the voltage across the leg (L-T) collapses.

Line Faults

The MV SMC-Flex™ controller continually monitors line conditions for abnormal factors. Pre-start protection includes:

- Line Fault (with phase indication)
  – Line voltage loss
  – Missing load connection
  – Shorted SCR

Running protection includes:

- Line Fault (no phase indication)
  – Line voltage loss
  – Missing load connection

Phase reversal protection ❶ can be toggled either ON or OFF.

❶ Phase reversal protection is functional only at pre-start.

Excessive Starts/Hour

The MV SMC-Flex™ module allows the user to program the desired number of starts per hour (up to 99). This helps eliminate motor stress caused by repeated starting over a short time period.

Note: The base rating of the MV SMC-Flex is two starts (thirty seconds each max.) per hour. Applications requiring more frequent starts, or longer duration starts, should be reviewed with the factory to avoid equipment damage.

Overtemperature

The power module temperature is monitored during starting and stopping maneuvers by thermistors. The thermistor is connected to the gate driver board where it is processed, and the status is transmitted by fibre-optic cable through the interface board to the control module. When an overtemperature condition exists (>85°C), the control module trips and indicates a "PTC Power Pole" fault.

An overtemperature condition could indicate high ambient temperature, overloading or excessive cycling. After the power module temperature is reduced to allowable levels, the fault can be cleared (see page 9-1 for instructions).

Metering

Power monitoring parameters include:

- Three-phase current
- Three-phase voltage
- Power in MW
- Power usage in MWh
- Power factor
- Motor thermal capacity usage
- Elapsed time
- Motor speed (full speed %, with use of optional tachometer input)

Notes:

1. Voltage measurement is not available during the braking operation of the SMB Smart Motor Braking, Accu-Stop, and Slow Speed with Braking control options.
2. The elapsed time and MWh values are automatically saved to memory every 12 hours.
3. Motor thermal capacity usage is determined by the built-in electronic thermal overload. An overload fault occurs when this value reaches 100%.

I/O

The SMC-Flex has the ability to accept up to two (2) inputs and four (4) outputs controlled over a network. The two inputs are controlled at terminal 16 (Option Input #1), and terminal 15 (Option Input #2). For these two inputs, see Chapter 4 for the parameter settings and see Chapter 8 for the bit identification. By using these two terminals as inputs, the Stop Input will need to be programmed to meet the desired stop functionality.

The four (4) outputs are Aux #1, Aux #2, Aux #3 and Aux #4. All auxiliary contacts are programmable to the function found on page 4-13. If programmed to Network or Network NC, they can be controlled over a Network. Please see Table 8.H which defines the Logic Command Word (Control).

Note: For MV applications, some of the I/O are assigned to specific functions. Please refer to "Notes" related to Status Indication (page 1-20) for additional details.

Communication

A serial interface port (DPI) is provided as standard, which allows connection to the Bulletin 20-HIM LCD human interface modules.

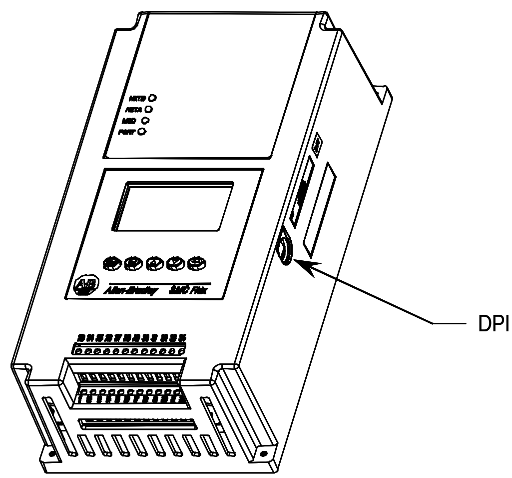


Figure 1.14 – DPI Location

ATTENTION

Two peripheral devices can be connected to the DPI. The maximum output current through the DPI is 280 mA.

Programming

Setup is easy with the built-in keypad and three-line, sixteen-character backlit LCD. Parameters are organized in a three-level menu structure, using a text format for straightforward programming.

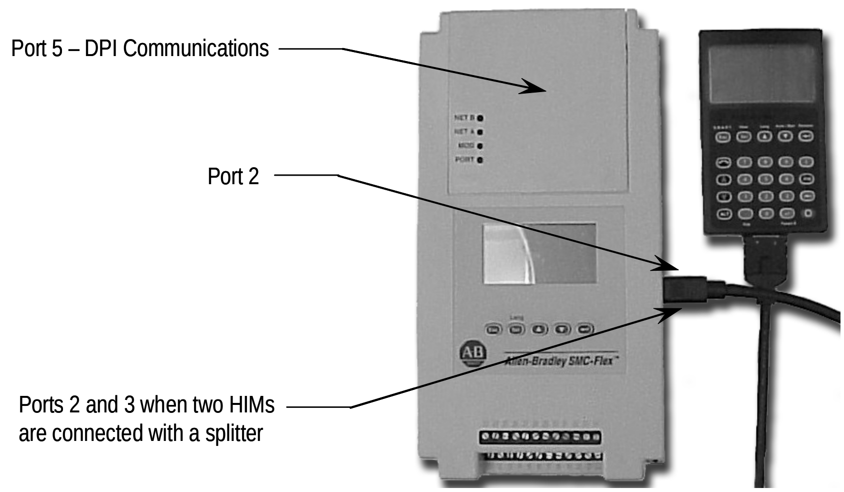


Figure 1.15 – Built-in Keypad and LCD

Status Indication

Four programmable hard contact outputs are provided as standard. All auxiliary contacts are programmed for the following states:

- Normal (N.O./N.C.)
- Up-to-Speed (N.O./N.C.)
- Alarm (N.O./N.C.)
- Fault (N.O./N.C.)
- Network Control (N.O./N.C.)
- External Bypass (N.O.)

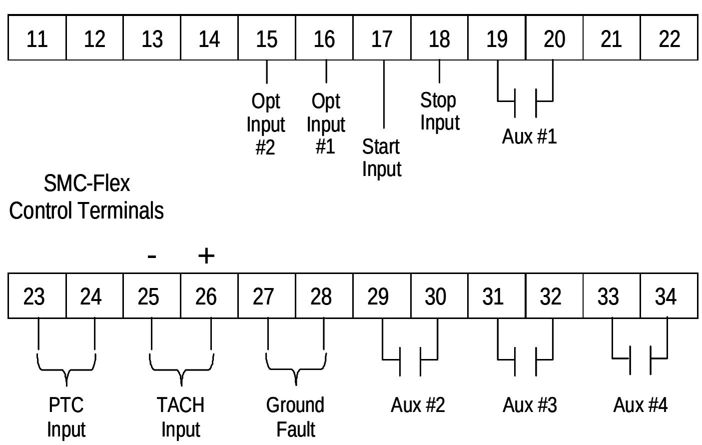


Figure 1.16 – Control Terminals

Status Indication (cont.)

Note:

- The Aux #1 contact is always programmed for Up-to-speed (N.O.) to control the bypass contactor in MV applications.
- The Aux #2 contact is typically programmed for fault indication in MV applications (it can be configured for N.O./N.C.).
- The Aux #3 contact is typically programmed for alarm indication in MV applications (it can be configured for N.O./N.C.).
- The Aux #4 contact is always configured as Normal (N.O.) to control the line contactor for MV applications.

Network inputs can be obtained through proper programming of Option Input #1 and Option Input #2.

Control Options

The MV SMC-Flex™ controller offers the control options described below.

Important: The options listed in this section are mutually exclusive and must be specified when ordering. An existing controller may be upgraded to another control option by replacing the control module and possibly other components. Consult your nearest Rockwell Automation sales office.

Pump Control Option

This option reduces surges during the starting and stopping of a centrifugal pump by smoothly accelerating and decelerating the motor. The microprocessor analyzes the motor variables and generates commands that control the motor and reduce the possibility of surges occurring in the system.

The motor current will vary during the acceleration period, and may be near the motor rated starting current. The pump algorithm does not limit starting current since full voltage is needed to reach full speed with a loaded motor.

The starting time is programmable from 0-30 seconds, and the stopping time is programmable from 0-120 seconds.

Kickstart is available with this option.

Pump Application Considerations

1. Consult factory if start time settings over 30 seconds are required. The base rating of the MV SMC-Flex is two starts (or one start/stop combination) per hour, thirty seconds maximum for each operation. A stopping operation counts as a start for purposes of thermal capacity calculations.

2. The Pump Control option functions *only* for centrifugal pumps. It is not suited for positive displacement, piston, or other types of pumps.

3. The Pump Stop option functions only for a centrifugal pump running at greater than approximately 2/3 of the motor rated horsepower.

4. Pump applications with input and/or output valves that are closed during starting and/or stopping may not benefit from the Pump Control option. Consult the factory for applications with valves.

5. For starting or stopping times longer than 15 seconds, power fuse selection should be reviewed to ensure no element damage occurs. The fuse minimum melting time-current characteristic curve should be consulted to ensure that, at 1.1 times the full voltage locked rotor current of the motor, the actual starting or stopping time does not exceed 75% of the fuse melting time.

6. Motor overload and/or upstream breaker settings may have to be adjusted to allow the starting or stopping current to flow for extended periods.

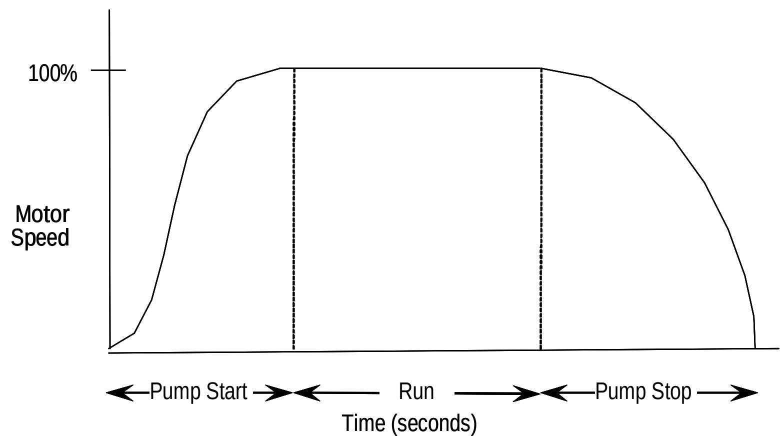


Figure 1.17 – Pump Control Option

ATTENTION Pump stopping is not intended to be used as an emergency stop. Refer to the applicable standard for emergency stop requirements.

ATTENTION Pump stopping may cause motor heating depending on the mechanical dynamics of the pumping system. Therefore, select the lowest stopping time setting that will satisfactorily stop the pump.

Braking Control Option

The Braking Control option (Smart Motor Braking, Accu-Stop and Slow Speed with Braking) are not offered for standard use in MV applications. Please consult factory for further assistance.

Hardware Description

The following sections contain descriptions of system components and system operation. Each section will be described to give the user an understanding of the MV SMC-Flex to facilitate operation and maintenance of the system. Refer to Figures 1.18 and 1.19, Typical MV SMC-Flex Power System.

Power Module

The controller consists of three power modules, one for each phase. Each power module consists of incoming and outgoing terminals for cables, SCRs, heatsink and clamp assembly. The SCRs are connected in inverse parallel (and in series for 12- or 18-SCR assemblies) to form a three-phase, AC line controller configuration.

Each power module includes a snubber circuit to limit the rate of rise in voltage across each SCR pair. The module also includes patented current loop gate driver circuits which derive their power primarily from the snubber circuit.

Voltage sharing resistors are connected across each SCR pair to provide static voltage balance for series-connected SCRs. These resistors are tapped to provide a reference for overvoltage protection circuitry on the gate driver board.

A voltage sensing board is used to reduce the line-side and load-side voltages to lower levels that can be measured by the SMC-Flex control module.

Current Loop Gate Driver (CLGD) Board

This board provides the turn-on capability for SCR devices. The board also provides optical fibre isolation between itself and the gating source logic. It is primarily powered by recovering energy from the snubber circuit, so it is fully isolated from the control and logic circuits. The board also receives short-term power from the current loop power supply.

The MV SMC-Flex has three heatsinks fitted with a thermistor to monitor temperature rise. The circuitry on the gate driver board accepts the thermistor, and drives a fibre-optic cable if the temperature is below the setpoint (85°C). If the temperature rises above the setpoint, the driver is turned off, and the MV SMC-Flex is signalled to stop gating and initiate a temperature fault.

Hardware Description (cont.)

Interface Board

This circuit board takes current transformer signals plus line-side and load-side voltage feedback signals from the voltage sensing board and passes them to the SMC-Flex for processing. The control module produces gating signals for the SCRs, which are received on the interface board, and used to drive fibre-optic transmitters. The gating signals are sent to the gate-driver circuit board via fibre-optic cables. The interface board also receives temperature feedback from the gate-driver board via fibre-optic cable(s). If the heatsink temperature rises above a set value, a signal is sent to the SMC-Flex to stop gating the SCRs and initiate a temperature fault.

For a detailed layout of this circuit board, refer to Figure 3.2 on page 3-6.

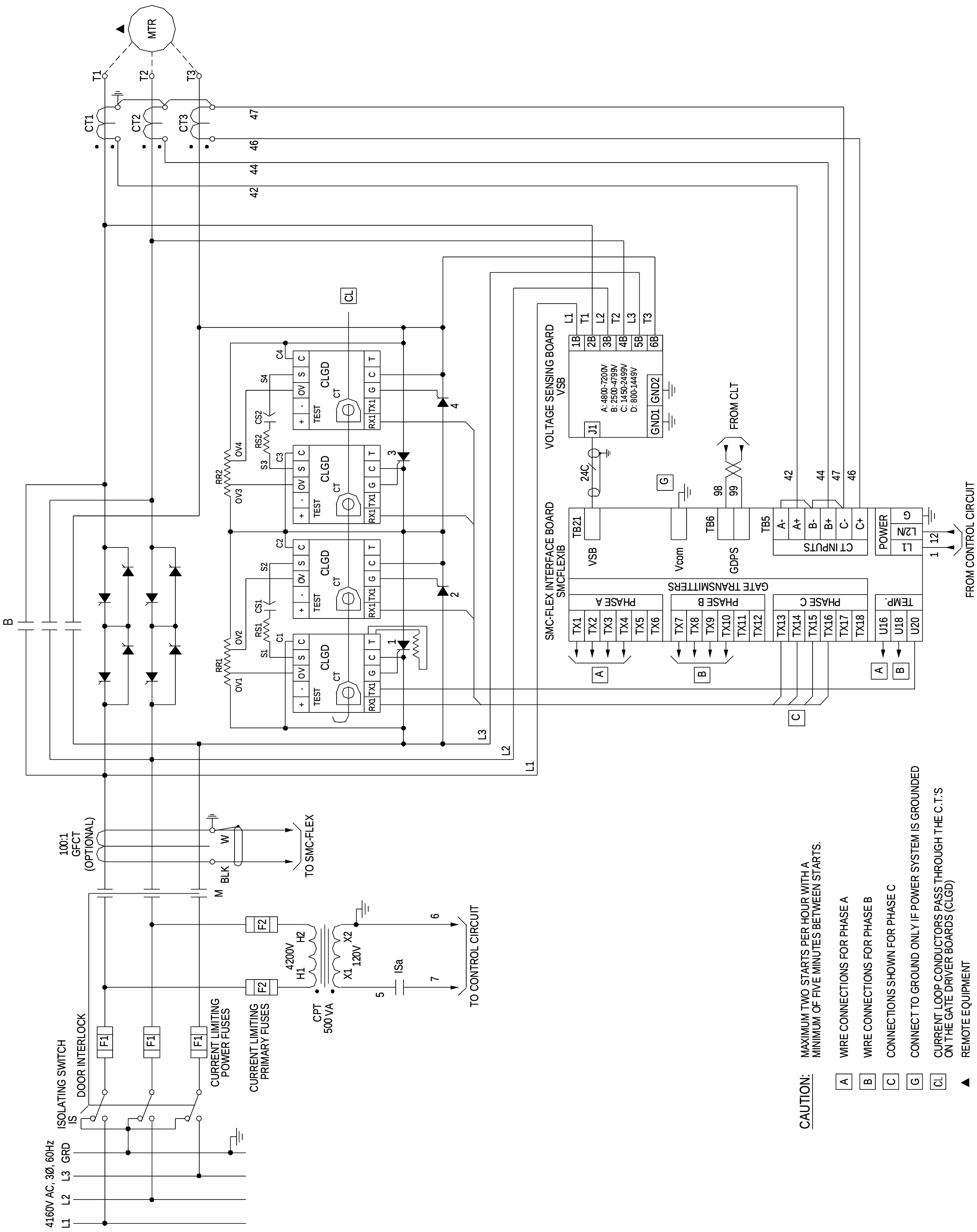


Figure 1.18 – Typical MV SMC-Flex Power System • Bulletin 1562E (3300/4160V shown)

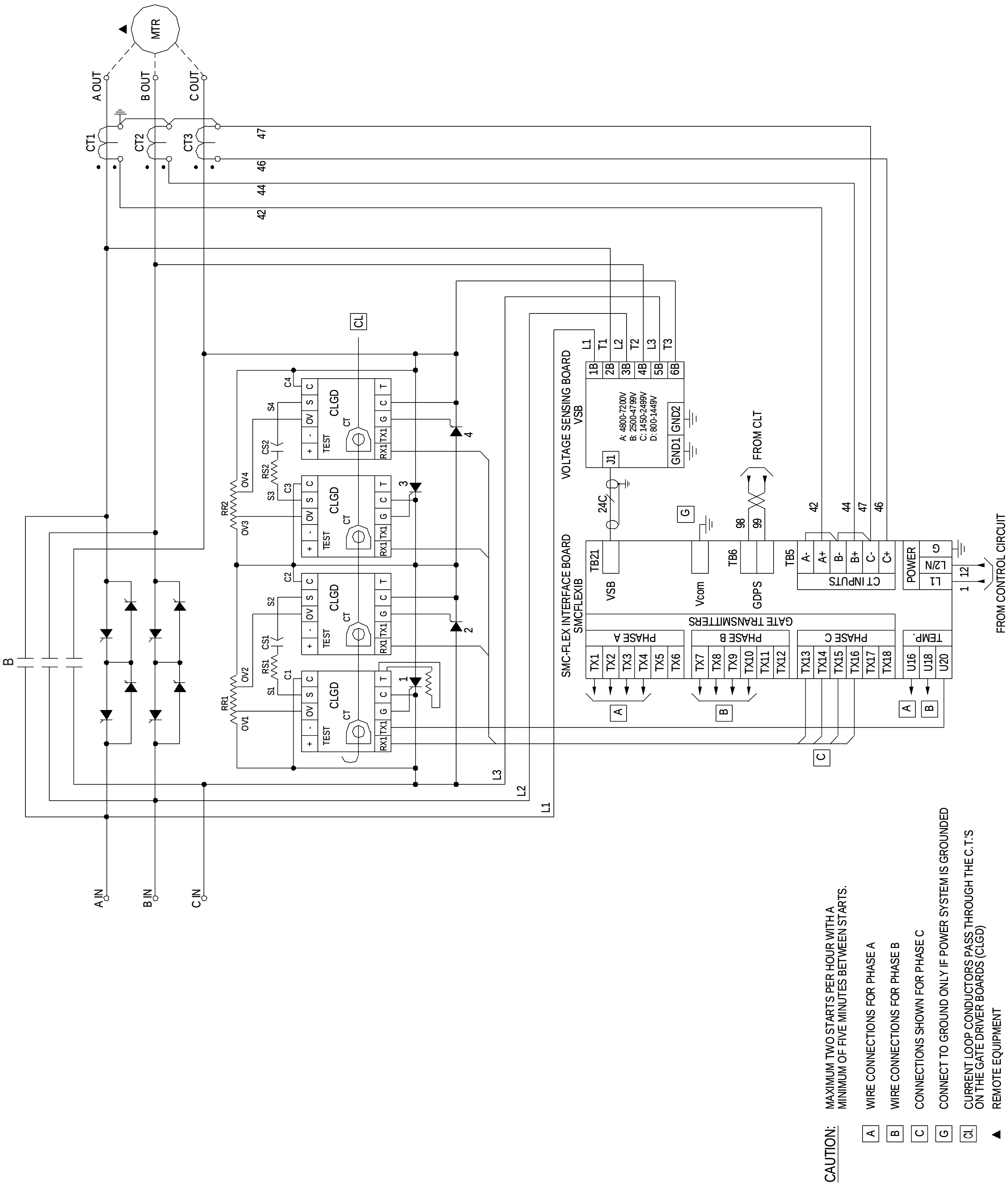


Figure 1.19 – Typical MV SMC-Flex Power System • Bulletin 1560E (3300/4160V shown)

Functional Description

The following functional descriptions and associated control circuits are for units using IntelliVAC contactor control modules. For units with electromechanical (relay) control, refer to Appendix C.

ATTENTION

The control circuit schematics shown below assume that control power is fed from the same source as the primary circuit. If external control power is used, additional control interlocking may be required to avoid unexpected motor start-up. The control interlock should ensure that a motor start request is not inadvertently applied when the primary circuit is disconnected.

Bulletin 1562E • Basic Control – Controlled Start only

When wired as shown in Figure 1.20, the controller operates as follows:

Pressing the "Start" button initiates the start sequence. Relay "CR" closes and applies control power to terminal 17 of the SMC-Flex module. The Aux #4 ("Normal") closes, energizing "M-IV" and "MC", which completes the hold-in circuit on the start button, and closes the main contactor.

The SMC-Flex module examines the line voltage, looks for fault conditions, checks phase rotation, calculates zero crossing information, and begins gating the SCRs to start the motor.

When the motor approaches rated speed, the SMC-Flex module closes the "Aux #1" (up-to-speed) auxiliary contacts, energizing "B-IV", which closes the bypass contactor. The motor then runs at full line voltage.

When the "Stop" button is pressed, the "CR" relay opens terminal 17 on the SMC-Flex module. The "Normal" contact opens, dropping out the main contactor, allowing the motor to stop. The "Aux #1" contact is held closed for a short time by the control module. This holds the bypass contactor closed for about 10 seconds to protect the power electronics from any voltage transients due to opening the motor circuits.

Functional Description (cont.)

Bulletin 1562E • Basic Control – With Controlled Stop

When wired as shown in Figure 1.21, the controller operates in much the same manner as in Figure 1.20.

Terminal 16 on the SMC-Flex module now controls the start and stop maneuvers. Terminal 16 must remain energized for the module to run. When the "Stop" button is pressed, and "CR" opens, the SMC-Flex module will initiate the option stop. An uncontrolled, or coast stop, is achieved by opening the connection to terminal 17. This contact should remain open to ensure all hold-in contacts clear, to prevent a re-start.

If the motor has started, the unit is in the bypass mode, and a trip occurs within the SMC-Flex module or from an external protection relay; "Aux #4" will open the line contactor immediately, and "Aux #1" will remain closed for 10 seconds. A trip due to an overload or fault condition will result in a "coast" stop.

Bulletin 1562E • DPI Control – Controlled Start only

The control scheme shown in Figure 1.22 allows the MV SMC-Flex to be controlled using DPI (Drive Programming Interface). This special usage of DPI includes provisions for a "Local" mode of control as well.

With the Local-Off-Remote selector switch in the "Remote" position, terminal 18 of the SMC-Flex module is energized, allowing a start command to be executed via DPI. The "Aux #4" contact closes, energizing both "M-IV" and "MC".

When the motor approaches rated speed, the SMC-Flex module closes "Aux #1", energizing "B-IV", which closes the bypass contactor.

To run in "Local" mode, the "CR" contact is used to initiate a start sequence (similar to Figure 1.20).

A stop command can be generated via DPI or by opening "CR", depending on the control mode.

Bulletin 1560E • Basic Control – Controlled Start Only

The Bulletin 1560E is intended for addition to an existing motor controller, which provides circuit isolation, motor switching, and overload and overcurrent protection. When wired as shown in Figure 1.23, the controller operates as follows:

When a start is initiated in the existing motor controller and the contactor (or breaker) closes, a contact must be supplied to tell the 1560E to start also. A "CR" contact will apply control voltage to terminal 17 of the SMC-Flex module.

When stopping the motor, the contactor in the existing controller will open, removing power from the motor, and then the “CR” relay. The bypass hold-in rung will keep the bypass contactor closed for a short time.

The “Fault” contact on the SMC-Flex module should be wired into the existing controller to trip the main contactor (or breaker) in the event of a fault condition sensed by the SMC-Flex module.

If possible, it is better to have the SMC-Flex module control the main contactor directly. In this case, the control circuit would look like, and function like, the descriptions above for the Bulletin 1562E.

Bulletin 1560E • Basic control – With Controlled Stop

When wired as shown in Figure 1.24, the controller operates much the same as described above for the Standard module. The control signal uses terminal 16 instead of 17, and a “coast” stop can be achieved by opening the connection to terminal 17.

It is more important in this configuration to integrate the control circuit of the 1560E with the existing controller, for better control of the Stop option. The “start signal” for this scheme cannot be a slave of the main contactor, since it must remain closed to accomplish the option stop maneuver. The SMC-Flex module can be used to control the main contactor such that it will close when a start is initiated, and remain closed until it has sensed the motor has stopped following an option stop maneuver.

Functional Description (cont.)

Bulletin 1560E • DPI Control – Controlled Start only

The control scheme shown in Figure 1.25 allows the MV SMC-Flex to be controlled using DPI. This special usage of DPI includes provisions for a "Local" mode of control as well.

With the Local-Off-Remote selector switch in the "Remote" position, and closure of the existing starter main contactor, terminal 18 is energized, allowing a start command to be executed via DPI. "Aux #4" serves as an interlock with the main contactor (or breaker) in the existing starter.

As with the other control schemes, the SMC-Flex module closes "Aux #1", energizing "B-IV", as the motor approaches rated speed.

Local control is enabled with the selector switch in the "Local" position. Closure of the "Start" relay, from the existing starter, allows the unit to initiate motor soft starting.

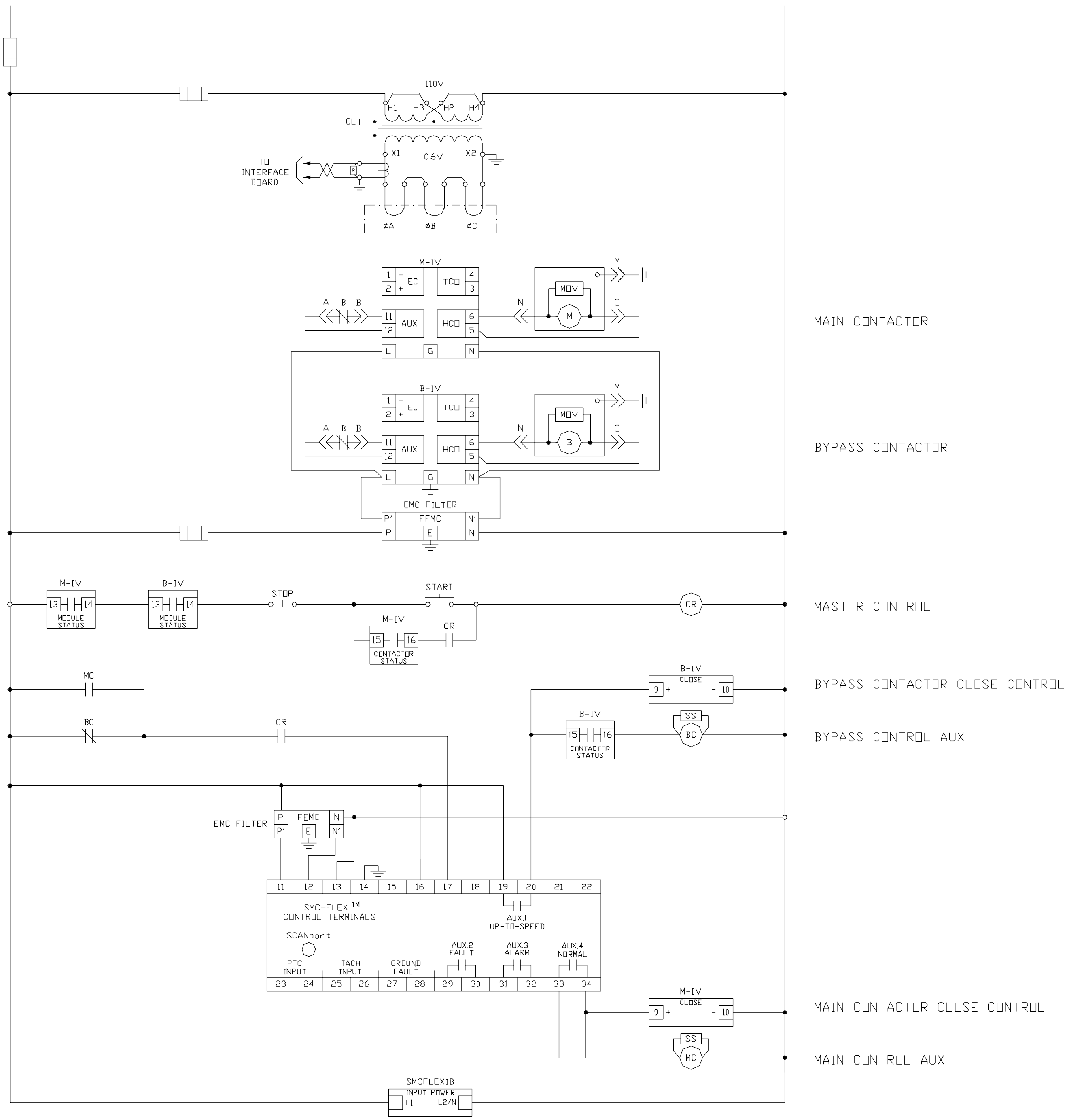


Figure 1.20 – Bulletin 1562E IntelliVAC Control Circuit • *Without* Stop Control

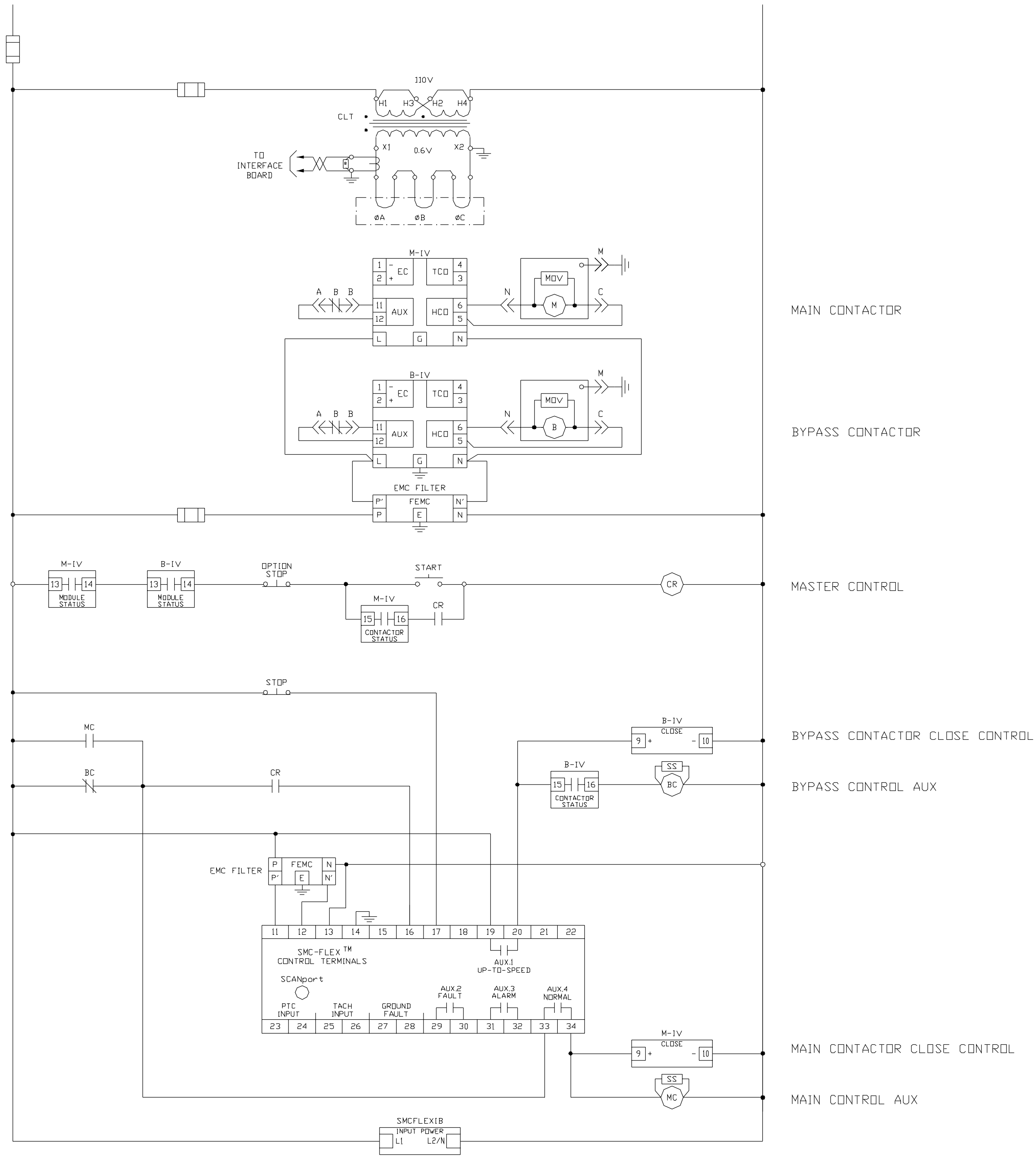


Figure 1.21 – Bulletin 1562E IntelliVAC Control Circuit • *With* Stop Control

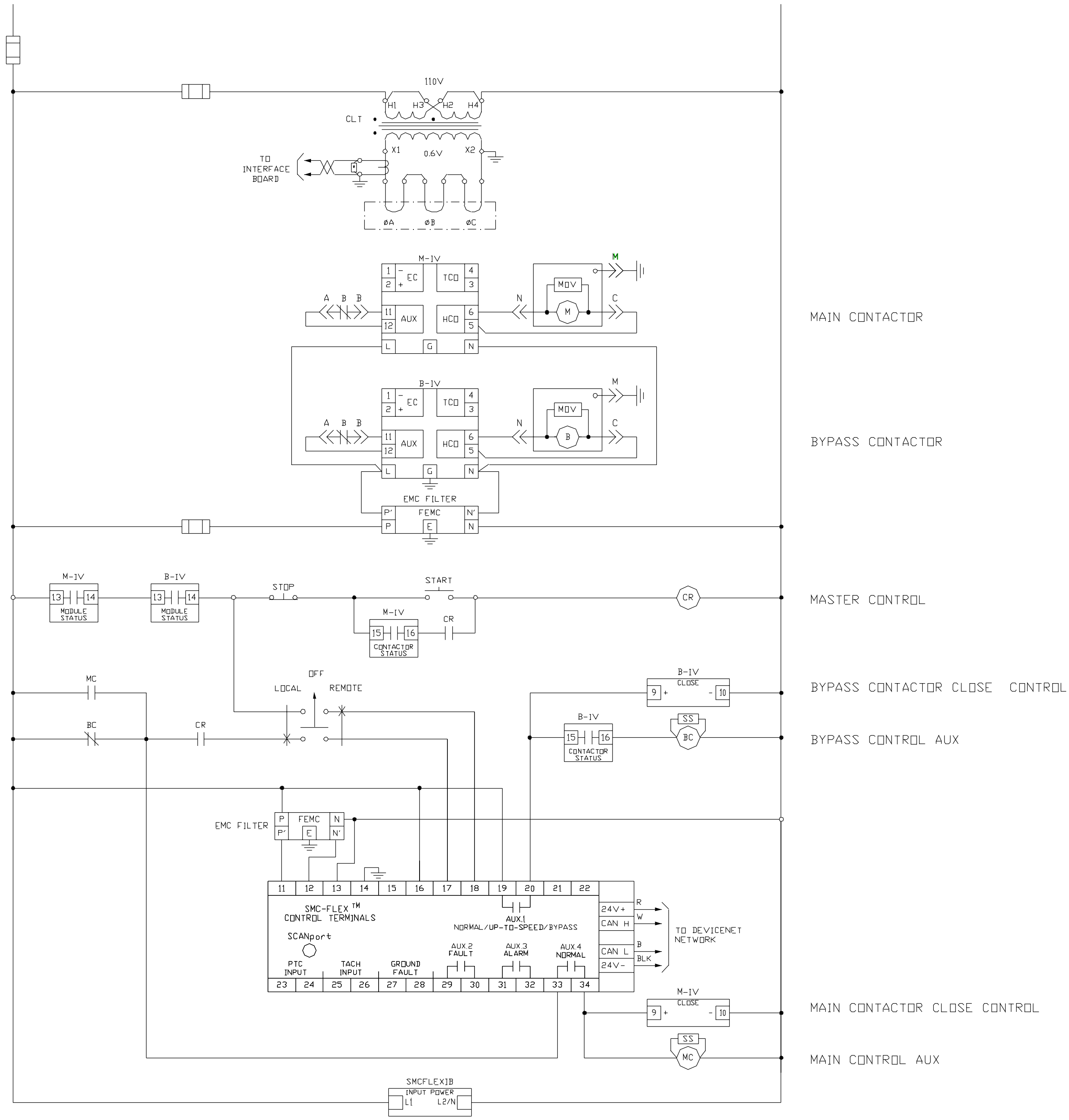


Figure 1.22 – Bulletin 1562E IntelliVAC Control Circuit
• *With* DeviceNet (or DPI) Communication and Optional Local/Off/Remote

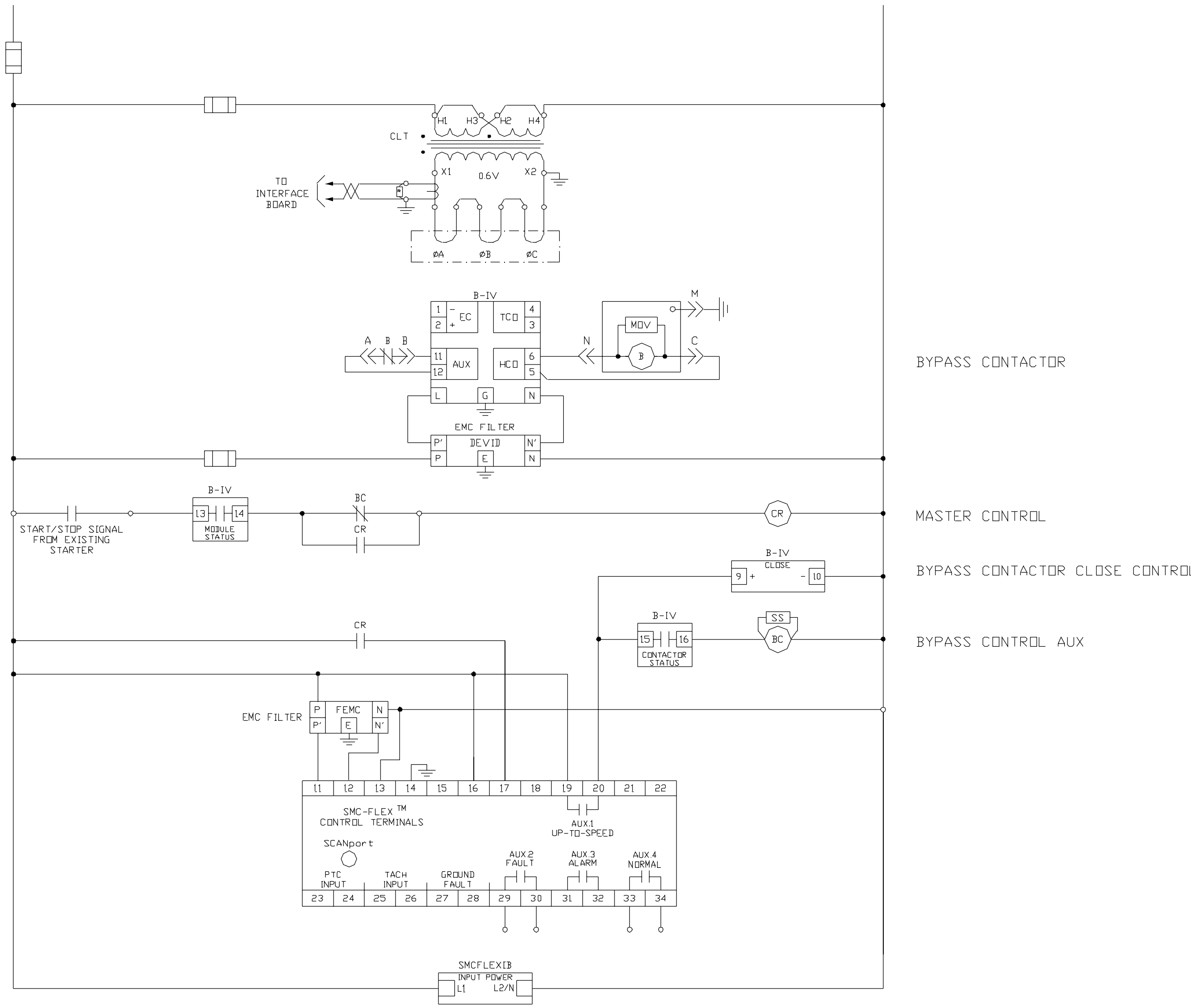


Figure 1.23 – Bulletin 1560E IntelliVAC Control Circuit • *Without* Stop Control

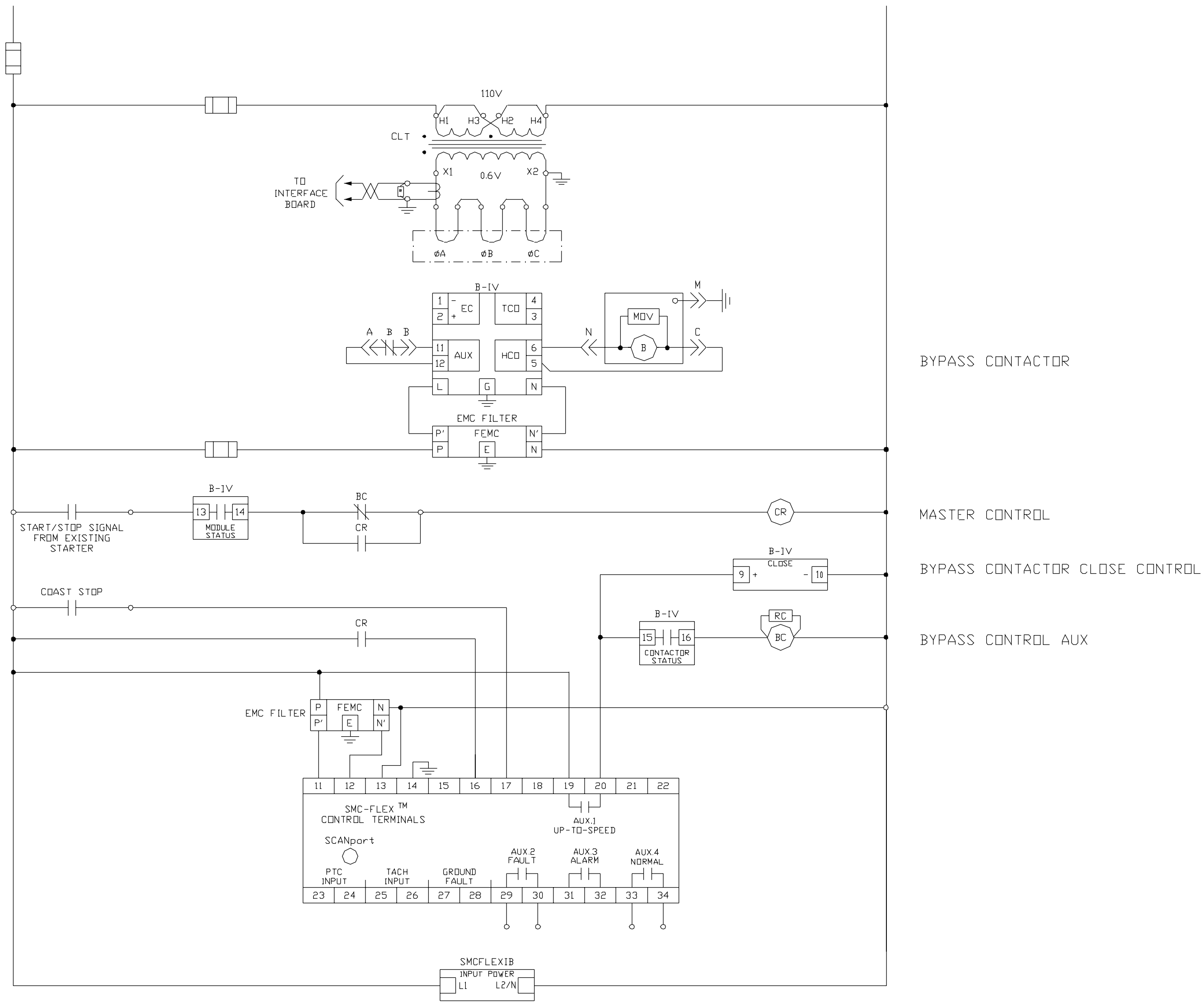


Figure 1.24 – Bulletin 1560E IntelliVAC Control Circuit • *With* Stop Control

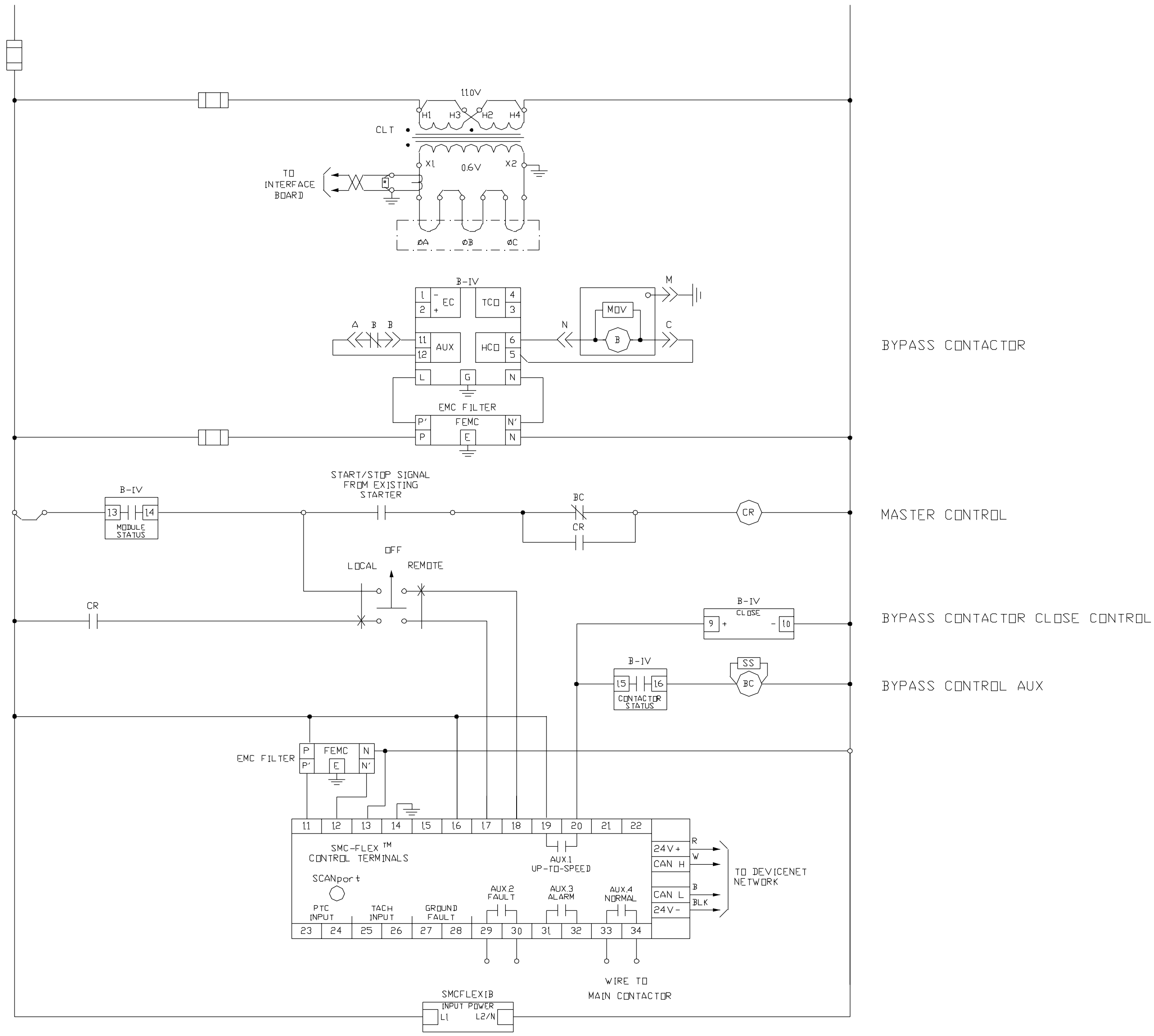


Figure 1.25 – Bulletin 1560E IntelliVAC Control Circuit
• *With* DeviceNet (or DPI) Communication and optional Local/Off/Remote

Installation

ATTENTION

Perform the installation duties correctly. Errors may cause commissioning delays, equipment damage or personal injury.

Important: For the 1503E, refer to applicable documentation from OEM installation, grounding, interlocking and wiring. This manual should be utilized in conjunction with the OEM supplied documentation, and is suitable for commissioning, programming, calibration, metering, serial communications, diagnostics, troubleshooting, and maintenance of a standard solid-state controller.

Receiving

It is the responsibility of the user to thoroughly inspect the equipment before accepting the shipment from the freight company. Check the item(s) received against the purchase order. If any items are damaged, it is the responsibility of the user not to accept delivery until the freight agent has noted the damage on the freight bill. Should any concealed damage be found during unpacking, it is again the responsibility of the user to notify the freight agent. The shipping container must be left intact and the freight agent should be requested to make a visual inspection of the equipment.

Safety and Codes

ATTENTION

The Canadian Electrical Code (CEC), National Electrical Code (NEC), or other local codes outline provisions for safely installing electrical equipment. Installation MUST comply with specifications regarding wire type, conductor sizes, branch circuit protection, interlocking and disconnect devices. Failure to do so may result in personal injury and/or equipment damage.

Unpacking and Inspection

After unpacking the material, check the item(s) received against the bill of lading to ensure that the nameplate description of each item agrees with the material ordered. Inspect the equipment for physical damage, as stated in the Rockwell Automation Conditions of Sale.

Remove all packing material, wedges, or braces from within the controller. Operate the contactors and relays manually to ensure that they operate freely. Store the equipment in a clean, dry place if it will not be installed immediately after unpacking. The storage temperature must be between -20°C and 75°C (-4°F and 167°F) with a maximum humidity of 95%, non-condensing, to guard against damage to temperature sensitive components in the controller.

General Precautions

In addition to the precautions listed throughout this manual, the following statements, which are general to the system, must be read and understood.

ATTENTION

The controller contains ESD (electrostatic discharge) sensitive parts and assemblies. Static control precautions are required when installing testing, servicing, or repairing the assembly. Component damage may result if ESD control procedures are not followed. If you are not familiar with static control procedures, refer to applicable ESD protection handbooks.

ATTENTION

An incorrectly applied or installed controller can damage components or reduce product life. Wiring or application errors, such as undersizing the motor, incorrect or inadequate AC supply, or excessive ambient temperatures, may result in malfunction of the system.

ATTENTION

Only personnel familiar with the controller and associated machinery should plan or implement the installation, start-up, and subsequent maintenance of the system. Failure to do this may result in personal injury and/or equipment damage.

Transportation and Handling

The controller must be transported on a pallet or via use of the lifting angles supplied as part of all 90-inch (2.3 m) high cabinets or frame units.

ATTENTION

Ensure that the load rating of the lifting device is sufficient to safely raise the controller sections. Failure to do so may result in severe injury and/or equipment damage. Refer to the packing slip enclosed with shipment for shipping weights.

Round rollers can be used to assist in moving the controller to the installation site. Once at the final site, the pipe rolling technique can be used to place the cabinet in the desired position.

ATTENTION

Care must be exercised when using either a forklift, or the pipe rolling technique, for positioning purposes to ensure that the equipment is not scratched, dented or damaged in any manner. Always exercise care to stabilize the controller during handling to guard against tipping and injury to personnel.

Installation Site

Consider the following when selecting the installation site:

A. The operating ambient temperature should be between 0°C and 40°C (32°F and 104°F) for NEMA Type 1 or 12 enclosures. For higher ambient conditions, please consult Rockwell Automation factory.

B. The relative humidity must not exceed 95%, non-condensing. Excessive humidity can cause electrical problems from corrosion or excessive dirt build-up.

C. The equipment must be kept clean. Dust build-up inside the enclosure inhibits proper cooling and decreases the system reliability. The equipment should not be located where liquid or solid contaminants can drop onto it. Controllers with ventilated enclosures (in particular those with fans) must be in a room free of airborne contaminants.

D. Only persons familiar with the function of the controller should have access to it.

E. The losses in the controller produce a definite heat dissipation, depending on the unit size, that tends to warm the air in the room. Attention must be given to the room ventilation and cooling requirements to ensure that the proper environmental conditions are met.

F. Operational altitude is 3,300 feet (1 km) maximum without derating. Higher altitudes may require optional components. Please consult Rockwell Automation factory.

G. The area of the controller should be free of radio frequency interference such as encountered with some welding units. This may cause erroneous fault conditions and shut down the system.

ATTENTION

An incorrectly applied or installed controller can result in component damage or a reduction in product life. Wiring or application errors, such as, undersizing the motor, incorrect or inadequate AC supply, or ambient temperatures above or below the specified temperature range may result in malfunction of the controller.

Mounting

The 1503E, 1560E and 1562E are designed to be mounted in the vertical position. Standard cabinet drawings with certified dimension drawings can be obtained by contacting your local Rockwell Automation Sales office for the 1560E/1562E. Please refer to OEM documentation for the 1503E. Refer to drawings for mounting requirements.

Installation Site (cont.)

Grounding Practices

The purpose of grounding is to:

A. Provide safety for Personnel.

B. Limit dangerous voltages to ground on exposed parts.

C. Facilitate proper overcurrent device operation under ground fault conditions.

D. Provide for electrical interference suppression.

Important: Generally, grounding should be in accordance with the Canadian Electrical Code (CEC) or National Electrical Code (NEC) and other local codes.

Each power feeder from the substation transformer to the controller must be equipped with properly sized ground cables. Simply utilizing the conduit or cable armour as a ground is not adequate. The conduit or cable armour and ground wires should be bonded to ground at both ends. Each enclosure and/or frame must be bonded to ground at a minimum of two locations.

Each AC motor frame must be bonded to grounded building steel within 20 feet (6.1 m) of its location and tied to the controller's ground bus by ground wires within the power cables and/or conduit. The conduit or cable armour should be bonded to ground at both ends.

ATTENTION

Any instruments used for test or troubleshooting should have their case connected to ground for safety. Failure to do so may result in damage to equipment or personal injury.

Recommended Torque Values

When reinstalling components or when reassembling the cabinet, tighten the following bolt sizes to the specified torque values:

Hardware	Recommended Torque
¼ in. (M6)	6 ft·lb (8 N·m)
5/16 in. (M8)	11 ft·lb (15 N·m)
3/8 in. (M10)	20 ft·lb (27 N·m)
½ in. (M12)	48 ft·lb (65 N·m)
Control Wire Terminals	2.0 – 3.3 in·lb (2.5 – 4.0 N·m)
CLGD Power Assembly Terminals	50 in·lb (5.6 N·m)
SMC-Flex Control Module Terminals	5 in·lb (0.6 N·m)

NOTE: For 3/8 in. hardware in the 'T'-slots of aluminum heatsinks, the recommended torque is 16 ft-lb (22 N-m). Do not overtorque these connections as the slots will be damaged and the connection will be compromised.

Power Connections

The controller requires a three-phase supply and an equipment grounding conductor to earth ground. A neutral conductor of the three-phase supply is not necessary and is usually not routed to the controller. Three-phase wiring will connect the controller to the motor.

Bulletin 1562E

The Bulletin 1562E unit is available in two main configurations:

1. A modified two-high cabinet (180/360A, 2400 to 4160 V)
2. A combination of a one-high full voltage non-reversing (FVNR) cabinet and a 1560E unit (600A, 2400 to 4160 V, and 180/360/600A, 5500 to 6900 V)

To make power connections for a two-high cabinet, refer to Figures 2.1 to 2.3, and Publication 1500-UM055B-EN-P (Chapter 2).

To make power connections for a one-high FVNR cabinet and a 1560E unit, proceed as follows:

- Make line connections within the one-high cabinet
- Make load connections at the 1512 CT terminals

Bulletin 1560E

Refer to Figures 2.4 to 2.6, depending on the rating of the unit.

- Make line connections to the line connection terminals
- Make load connections to the current transformer terminals

Power Connections (cont.)

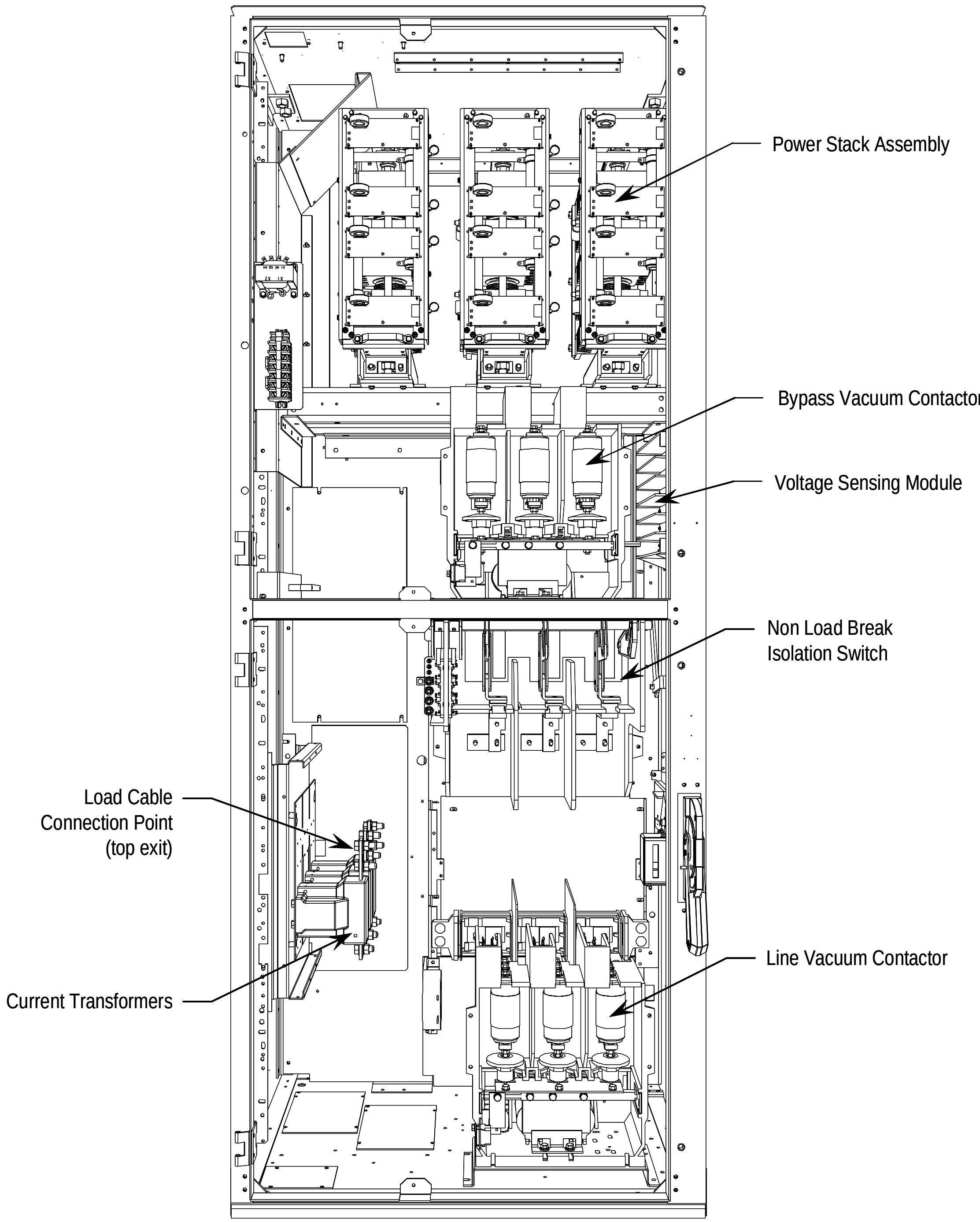


Figure 2.1 – Cabinet Layout • 1562E – 180/360 A, 2400 V to 4160 V
(with LV panels not shown)

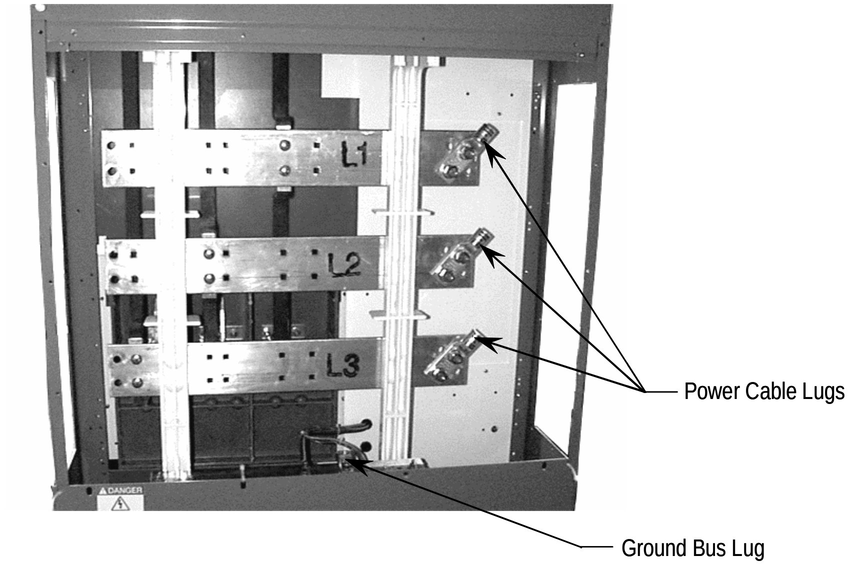


Figure 2.2 – Incoming Line Cable Connections
(viewed from the rear with power bus access cover removed)

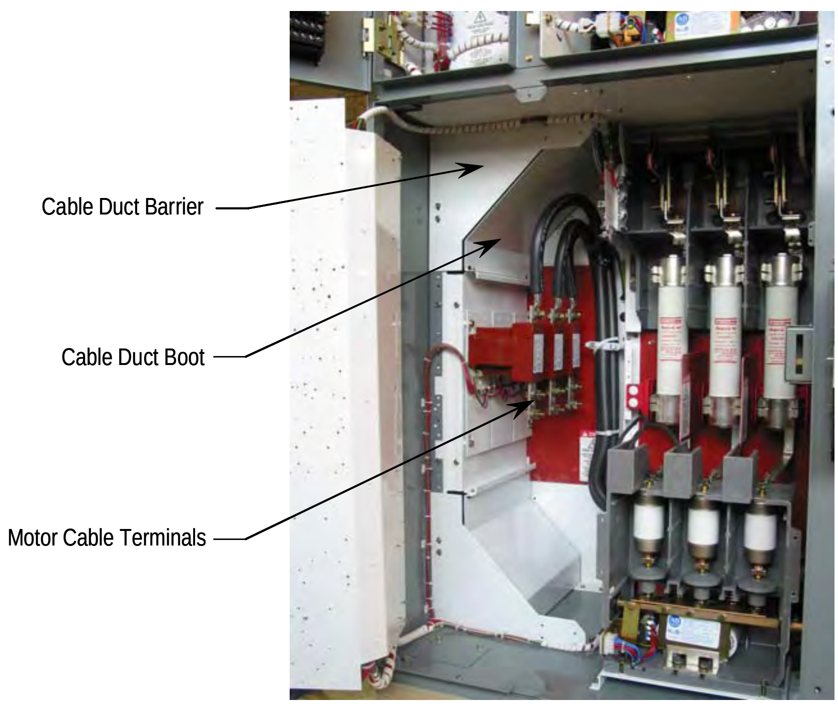


Figure 2.3 – Bottom Cable Exit Configuration
(with LV panel swung open)

Power Connections (cont.)

Bulletin 1560E

Refer to Figures 2.4 to 2.6 to make power connections for a 1560E unit.

Note: The CT assembly can be oriented to allow either top or bottom load cable exit.

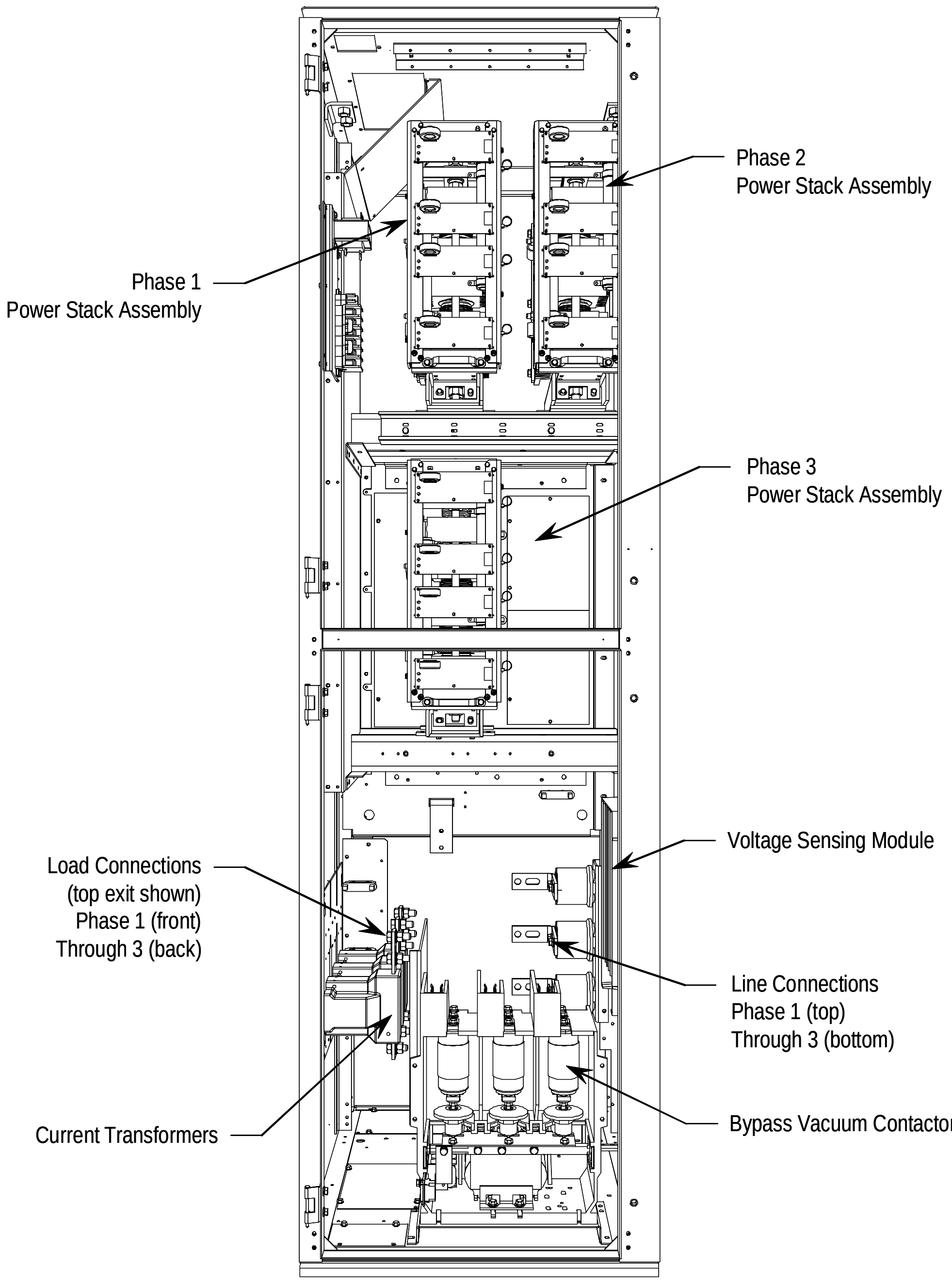


Figure 2.4 – Power Connections • 1560E – 180/360A, 2400 to 4160 V

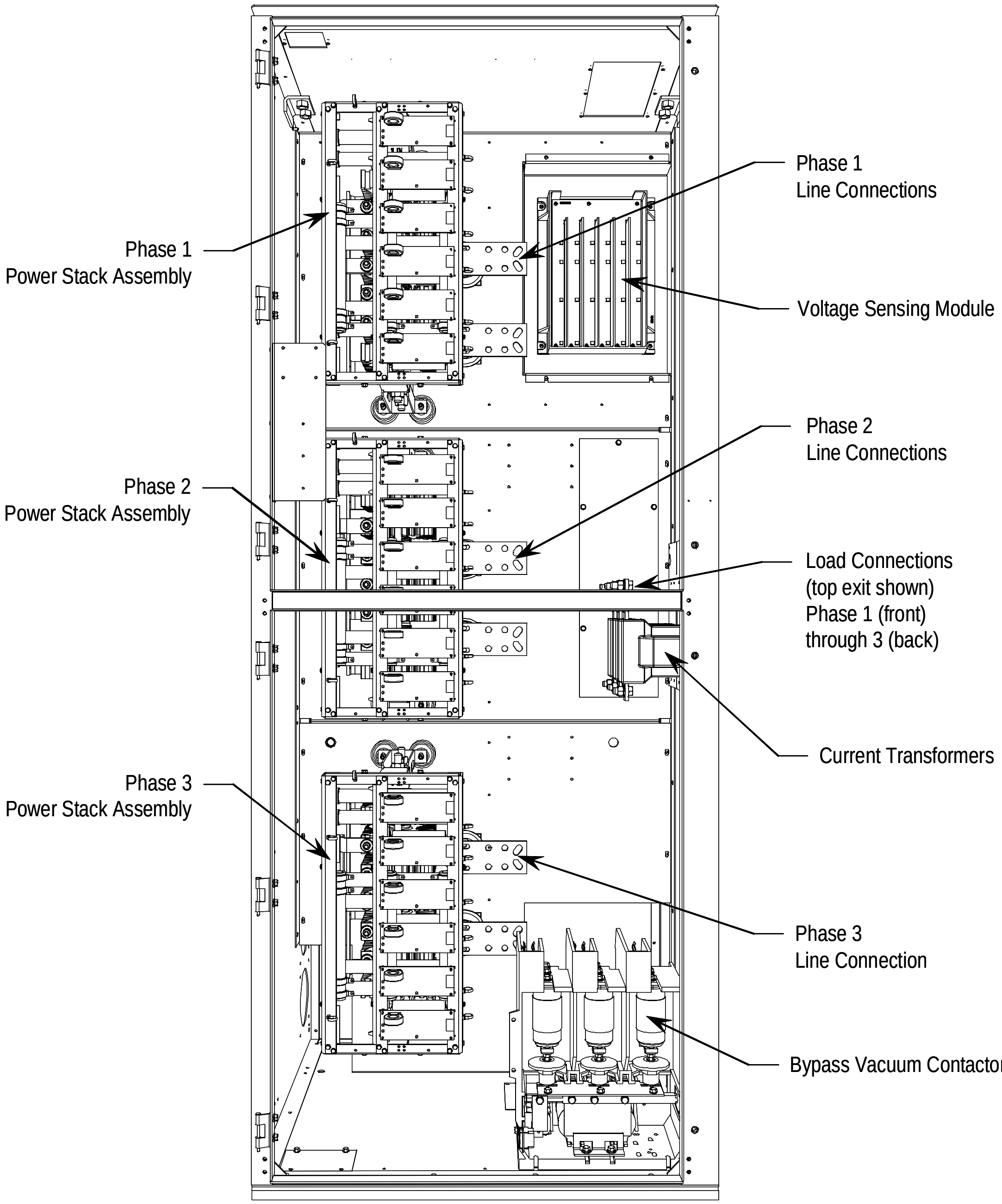


Figure 2.5 – Power Connections • 1560E – 180/360A, 5500 to 6900 V

Power Connections (cont.)

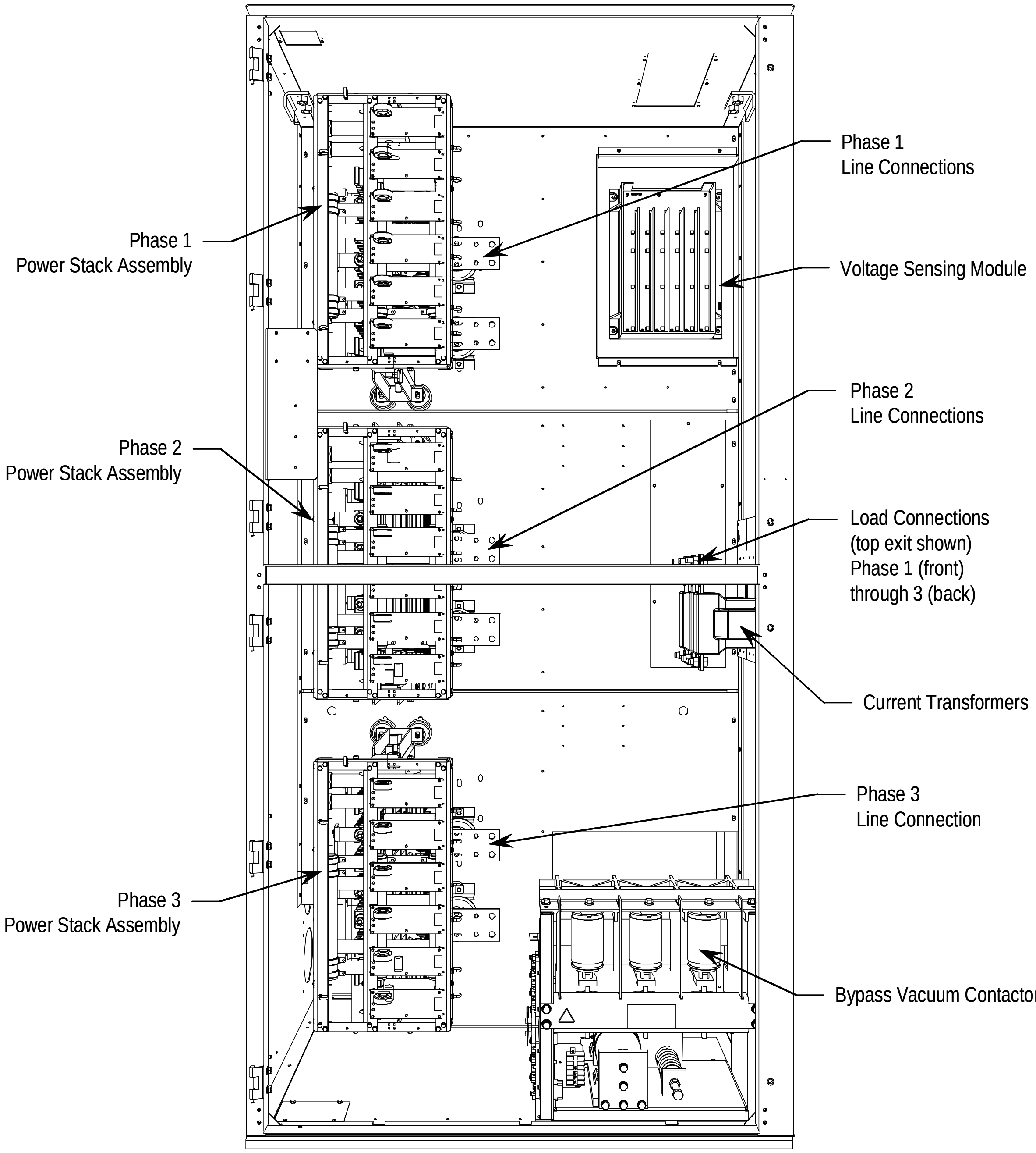


Figure 2.6 – Power Connections • 1560E – 600A, 2400 to 6900 V

Important: For retrofit units (Bul. 1560E), the CEC and NEC require that branch-circuit protection of the AC line input to the controller be provided by a circuit breaker or motor starter. This function is included with a Bulletin 1562E.

Important: The control and signal wires should be positioned at least six (6) inches (150 mm) from power cables. Additional noise suppression practices (including separate steel conduits for signal leads, etc.) are recommended.

Bulletin 1503E

For 1503E, refer to applicable documentation from OEM for installation, grounding, interlocking and wiring. This manual should be utilized in conjunction with the OEM supplied documentation, and is suitable for commissioning, programming, calibration, metering, serial communications, diagnostics, troubleshooting, and maintenance of a standard solid-state controller.

Power Wiring

The wire sizes must be selected individually, observing all applicable safety and CEC or NEC regulations. The minimum permissible wire size does not necessarily result in the best operating economy. The minimum recommended size for the wires between the controller and the motor is the same as that used if a main voltage source connection to the motor was used. The distance between the controller and motor may affect the size of the conductors used.

Consult the wiring diagrams and appropriate CEC or NEC regulations to determine correct power wiring. If assistance is needed, contact your area Rockwell Automation Sales Office.

Interlocking

Hinged doors and panels, which provide access to medium voltage components, must be mechanically interlocked to ensure circuit isolation. If a combination MV SMC-Flex (1562E) is purchased from Rockwell Automation, all medium voltage compartments will be mechanically interlocked such that they cannot be opened unless the isolating switch for the unit is open. Each medium voltage door is interlocked to the isolating switch handle. To open the doors, move the isolating switch to the OFF position and loosen the two retaining bolts on the main power cell door. Once this door is open, the other doors may be opened in sequence, depending on the specific interlock scheme provided. The retrofit-type MV SMC-Flex (1560E) is intended to be added to an existing motor controller, and has no isolating means included.

ATTENTION

For 1503E and 1560E, it is the responsibility of the installer/user to ensure the equipment interlocking scheme is in place and functional before energizing the equipment. Inadequate interlocking could expose personnel to energized parts which could result in severe burns, injury or death.

NOTE: Rockwell Automation can assist with the selection of an appropriate interlocking method, which may include mechanical modifications to the cabinet(s) or key-type lock systems.

NOTE: An auxiliary cabinet may be attached to the main structure. It will be ram-interlocked with the main power cell door, which will not allow it to be opened until the main power cell door is opened.

Installation

Physical Location

The controller is designed for limited front access (components may have to be removed) and should be installed with adequate and safe clearance to allow for total door opening. The back of the unit may be placed against a wall and several units may be set end to end. In special cases where floor space is limited and the unit is not against a wall, certain cabinet sections may be placed back to back. This requirement must be stated in the specifications in order to mechanically alter the controller.

Fan

The controller may include a cooling fan which is used to cool the component. It should be checked for free operation and no obstruction of the airflow.

Ground Bus Bar

Controllers which are delivered in two (or more) sections, or retrofit controllers, will require that the ground bus bar (6 mm x 51 mm) [¼ in. x 2 inches], which runs the entire length of the equipment in the center back side, be reconnected. A mechanical lug for #8-#10 AWG or #6-250 MCM cable is supplied at the incoming end of the line-up. When the sections are brought together, bus links are used to connect the bus bars.

Important: Refer to 2-high, Series B drawings in Publication 1500-UM055B-EN-P for power/ground bus connection.

Power and Control Wiring

Controllers consisting of two or more sections will require that the power and control wiring be connected per the schematic drawings provided.

Control Cables

Control cable entry/exit should be located near the terminal blocks; customer's connections are to be routed along the empty side of the terminals. Nylon cable tie loops are provided at the left, front corner of the cabinet to route control cables safely behind the low voltage panel hinges. Cables should be routed so they do not interfere with the swing of the low-voltage panels.

Fibre-Optic Cables

The small, gray, fibre-optic cables are fragile and must be protected during installation from sharp bends and impact.

Installation (cont.)

Power Factor Correction Capacitors

The controller can be installed on a system with power factor correction capacitors. The capacitors must be located on the line side of the controller. This is required to prevent damage to the SCRs in the MV SMC-Flex controller. A separate switching contactor is recommended to apply the capacitors only after the bypass contactor has closed, and to remove them when the bypass contactor opens. See Figure 2.7 for two different acceptable connection methods.

NOTE: *Consult the factory if there are any capacitors on the same branch circuit as the MV SMC-Flex.*

When discharged, a capacitor has essentially zero impedance. For switching, sufficient impedance should be connected in series with the capacitor bank to limit the inrush current. A method of limiting the surge current is to add inductance in the capacitor conductors. This can be accomplished by putting turns or coils of wire in the power connections to the capacitors (6-inch diameter coil, six loops). For more information, refer to NEMA standard ICS 2, Part 2, Capacitor Applications.

Care should be used in mounting the coils so that they are not stacked directly on top of each other or they will have a cancelling effect. Also, the coils should be mounted on insulated supports away from metal parts so they will not act like induction heaters.

ATTENTION

Any covers or barriers removed during installation must be replaced and securely fastened before energizing equipment. Failure to do so may result in severe burns, injury or death.

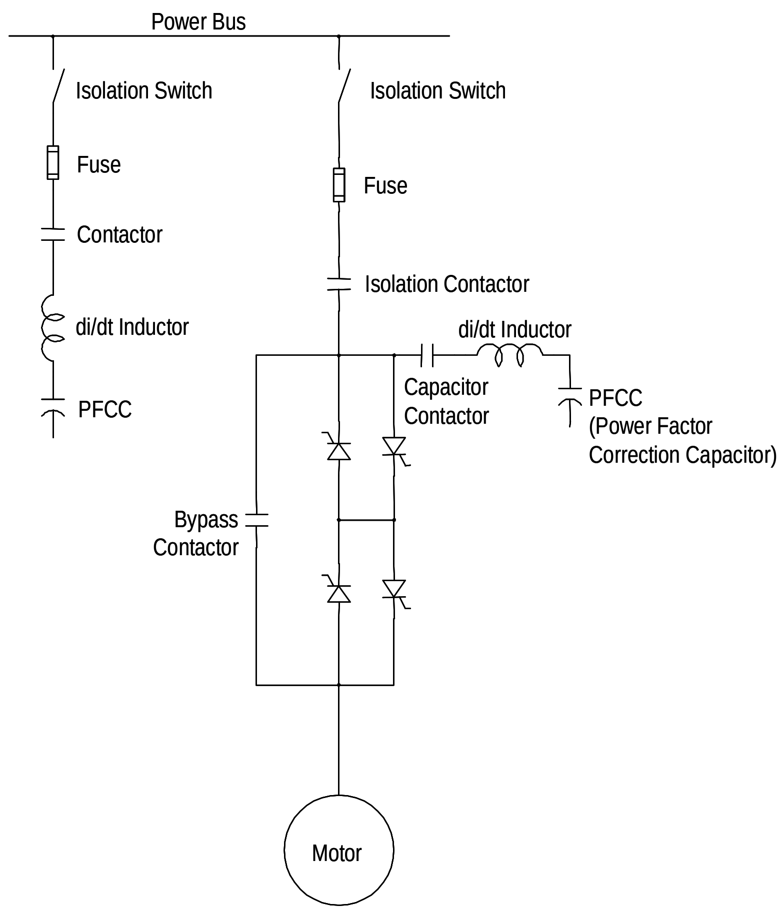


Figure 2.7 – Typical One-Line Diagram
(Showing 2 Different Styles of Power Factor Capacitor Connections)

Surge Arrestor Protection Devices

Rockwell Automation highly recommends that motor surge capacitors and/or motor surge arresters not be located on the load side of the SMC. The issues that warrant this are:

- Motor and system inductance limits the rate at which the current can change through the SMC. If capacitance is added at the motor, the inductance is negated. The surge capacitors downstream of the SMC represent a near zero impedance when presented with a step voltage from the turn on of the SCRs near the line voltage peak. This causes a high level of di/dt to occur, due to the fact that the motor cables are generally short in length. There is very little impedance between the capacitor and SCR to limit the di/dt of this capacitor charging current. This can result in damage to the power semiconductors (SCRs) in the SMC.

- It is essential to understand the clamping voltage of the arresters and type of grounding used in the distribution system. The switching of the SCRs generates slightly higher than nominal peak line to ground voltages. The typical peaks are 1.5 times the nominal line to ground peak voltages. These may cause the arresters to conduct, which could affect the operation of the SMC and result in faults. Depending upon the instance at which the arresters conduct, this could also result in SCR damage.

- The capacitance in combination with the line and motor impedance could also be excited by the voltage steps from SCR switching to create resonant voltage swings which could exceed the device voltage withstanding ratings or surge arrester rating, or cause distorted voltage signals which may be misinterpreted by the MV SMC-Flex control system.

Motor Overload Protection

Thermal motor overload protection is provided as standard (though it must be programmed) with the MV SMC-Flex controller. If the overload trip class is less than the acceleration time of the motor, nuisance tripping may occur.

ATTENTION

Overload protection should be properly coordinated with the motor to avoid damage to equipment.

Two special applications require consideration: Two-speed Motors, and Multi-motor Protection.

Two-speed Motors

The MV SMC-Flex controller has overload protection available for single speed motors. When the MV SMC-Flex controller is applied to a two-speed motor, the Overload Class parameter must be programmed to OFF, and separate overload relays must be provided for each speed.

Multi-motor Protection

The MV SMC-Flex controller provides overload protection for only one motor. When the MV SMC-Flex is controlling more than one motor, the Overload Class Parameter must be programmed to OFF, and individual overload protection is required for each motor.

EMC Compliance

ATTENTION

This product has been designed for Class A equipment. Use of the product in domestic environments may cause radio interference, in which case, the installer may need to employ additional mitigation methods.

The following guidelines are provided for EMC installation compliance.

Enclosure

Install the product in a grounded metal enclosure.

Wiring

Wire in an industrial control application can be divided into three groups: power, control, and signal. The following recommendations for physical separation between these groups is provided to reduce the coupling effect.

- Different wire groups should cross at 90° inside an enclosure.
- Minimum spacing between different wire groups in the same tray should be 16 cm (6 in.).
- Wire runs outside an enclosure should be run in conduit or have shielding/armor with equivalent attenuation.
- Different wire groups should be run in separate conduits.
- Minimum spacing between conduits containing different wire groups should be 8 cm (3 in.).
- For additional guidelines, please refer to Wiring and Ground guidelines, publication DRIVES-IN001A-EN-P.
- Wire earth ground to control terminal 14.
- Use shielded wire for: PTC Input
Tach Input
Ground Fault Input
- Terminate shielded wires to terminal 14.
- Ground fault CT must be inside or within 3 m of metal enclosure.

- To meet produce susceptibility requirements, ferrite cores need to be added to the communication lines. All cores specified below are the split core type, so they can be added to existing connections.
  - When using an external HIM (or DPI interface), a core should be added to the HIM cable near the SMC-Flex control module. The recommended core is Fair-Rite no. 0431167281 or equivalent.
  - When using DeviceNet, two cores need to be added to the DeviceNet cable near the SMC-Flex control module. The recommended cores are TDK ZCAT2033 0930H and TDK ZCAT2035 0930 or equivalent.

Control Power

Control Voltage

The SMC-Flex controller will accept a control power input of 100 to 240V AC, (-15 / +10%), 1 phase, 50/60 Hz. Refer to the product nameplate to verify the control power input voltage.

Connect control power to the controller at terminals 11 and 12. The control power requirement for the control module is 75 VA. Depending on the specific application, additional control circuit transformer VA capacity may be required.

Control Wiring

Table 2.C provides the control terminal wire capacity and the tightening torque requirements. Each control terminal will accept a maximum of two wires.

Table 2.C – Control Wiring and Tightening Torque

Wire Size	Torque
0.75 to 2.5 mm^2 (#18 to #14 AWG)	0.6 Nm (5 lb-in.)

Control Terminal Designations

As shown in Figure 2.10, the SMC-Flex controller contains 24 control terminals on the front of the controller.

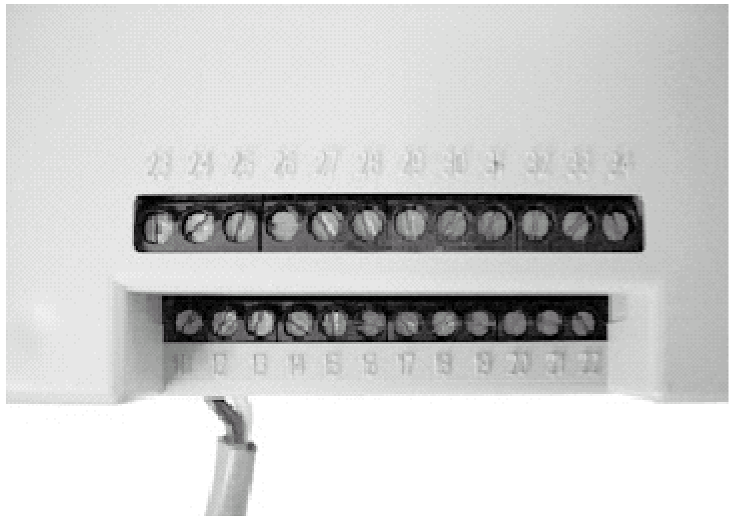


Figure 2.10 – SMC-Flex Controller Control Terminals

Terminal Number	Description
11	Control Power Input ❹
12	Control Power Common ❹
13	Control Enable Input ❶
14	Control Module Ground
15	Option Input #2 ❶ ❹
16	Option Input #1 ❶ ❹
17	Start Input ❶ ❹
18	Stop Input ❶ ❹
19	Aux. Contact #1 (Up-to-Speed) ❷ ❹
20	Aux. Contact #1 (Up-to-Speed) ❷ ❹
21	Not Used
22	Not Used

Terminal Number	Description
23	PTC Input ❶
24	PTC Input ❶
25	Tach Input (-)
26	Tach Input (+)
27	Ground Fault Transformer Input ❶
28	Ground Fault Transformer Input ❶
29	Aux. Contact #2 ❹
30	Aux. Contact #2 ❹
31	Aux. Contact #3 ❹
32	Aux. Contact #3 ❹
33	Aux. Contact #4 (Normal) ❸ ❹
34	Aux. Contact #4 (Normal) ❸ ❹

❶ Do not connect any additional loads to these terminals. These “parasitic” loads may cause problems with operation, which may result in false starting and stopping.

❷ Aux. Contact #1 is always programmed for Up-to-Speed (N.O.) to control the bypass contactor in MV applications.

❸ Aux. Contact #4 is always programmed for “Normal” (N.O.) indication in MV applications.

❹ RC snubbers are required on inductive loads connected to auxiliary.

Note: The OFF state leakage current for a solid-state device connected to an SMC-Flex input must be less than 6 mA.

Commissioning Procedure

Preliminary Set-Up

A. Ensure the work area is clean and tidy. Pathways to main disconnect and emergency stop push-button must be clear and unobstructed.

B. The following test equipment is to be prepared for use:

- Test power supply, supplied with each controller
- Multimeters
- Hi-Pot Tester (recommended) or Megger
- Oscilloscope with memory (optional)

C. Complete drawing package and parts list.

D. Specification of project.

System Characteristics

Job Name: ______________________________ Job Number: _________________________________

Rated Voltage: __________________________ Rated Current: _____________ S.F.: _________

Actual Motor Load

Load Type: Fan ___Pump___Conveyor___Compressor___Mixer___

Other____

Constant Torque_______ *or* Variable Torque _______

Actual Motor Data: ____

Motor HP: ____

Motor Rated Speed: ____

Motor F.L.A.: ____

Motor S.F.: ____

Motor L.R.A.: ____

Frequency: ____

Phases: ____

Preliminary Check

ATTENTION

Ensure that all sources of power are isolated and locked out before working on installed equipment. Verify that all circuits are voltage free using a hot stick or appropriate voltage measuring device. Failure to do so may result in severe burns, injury or death.

A. Verify correct power cable phase sequencing, and that connections are tight.

B. Verify power fuse ratings and condition.

C. Verify control fuse ratings and condition.

D. Check that power cable installation has not damaged components, and that electrical spacings have not been reduced.

E. Check that fibre-optic cables are fully seated in their connectors.

F. Check that circuit board plug connectors are installed and fully inserted in their sockets.

G. Check that the cooling fan (if supplied) is secured and the rotor is not obstructed.

H. Verify integrity and operation of all interlocks.

I. In the case of the 1503E, verify wiring and perform all tests in conjunction with OEM documentation.

Programming

MV SMC-Flex™ Module

Refer to Chapter 4 for programming procedures.

The default (factory) parameter settings are as shown in Appendix B.

Settings may be different on engineered orders, or when option modules or customer requirements dictate different settings.

Important: The module should be programmed with an understanding of how the SMC functions, and the characteristics of the motor and driven load. Inappropriate settings may elicit unexpected results such as lack of acceleration torque or full-voltage starting. For Pump Control applications, refer to Application Considerations on page 1-20.

If the factory settings are not suitable for the application, program the module to meet the application requirements. Contact your local Rockwell Automation representative or the factory if assistance is required.

Hi-Pot and Megger Test

It is recommended that insulation levels be checked before energizing power equipment. This may be done with a High Voltage AC insulation tester (HI-POT) or a Megger. See Vacuum Contactor User Manual for suggested HI-POT testers, and for test procedures for vacuum contactors. If using a Megger, a 5000 volt type is recommended.

ATTENTION

Solid-state devices can be destroyed by high voltage. **Use jumper wires between heatsinks to short out the SCRs before applying high test voltages to the power circuit.** Disconnect the white wires (L1, T1, L2, T2, L3, T3) from the voltage sensing board and remove the plug connector. If voltage transformers are present, remove one primary fuse from each device. On the 1503E, consult OEM documentation for location of voltage sensing board

ATTENTION

Use caution when performing the HI-POT or Megger Test. High voltage testing is potentially hazardous and may cause severe burns, injury or death. Where appropriate, the case of the test equipment should be connected to ground.

Insulation may be tested from phase to phase and phase to ground. The recommended level for AC HI-POT testing is ($2 \times V_{LL}$) Volts, where V_{LL} is the rated line-to-line voltage of the power system. The leakage current may be recorded for future comparison testing, and must be less than 20 mA.

If a Megger is used, it should indicate 50 k megohms or greater if it is isolated as explained in the next paragraph. If the motor is connected, the Megger should indicate 5 k megohms or greater.

If a 1560E is being tested, it is recommended that the input and output cables be disconnected for each phase. If a 1562E is being tested, it is recommended that the main contactor be in the open position, and that the output cables be disconnected for each phase. (See points marked with an asterisk * in Figure 3.1) This will ensure the unit is isolated from the line and the motor. The line and the motor may be tested separately to locate problem areas. If a 1503E is being tested, consult OEM documentation.

After completing the test, remove all semiconductor jumpers and test the devices with a multimeter to ensure no damage has occurred from the insulation test. Reconnect the system as it existed prior to this section. Perform the power supply and resistance checks in the following sections.

ATTENTION

Failure to reconnect all wires and cables correctly may result in equipment damage, personal injury or death.

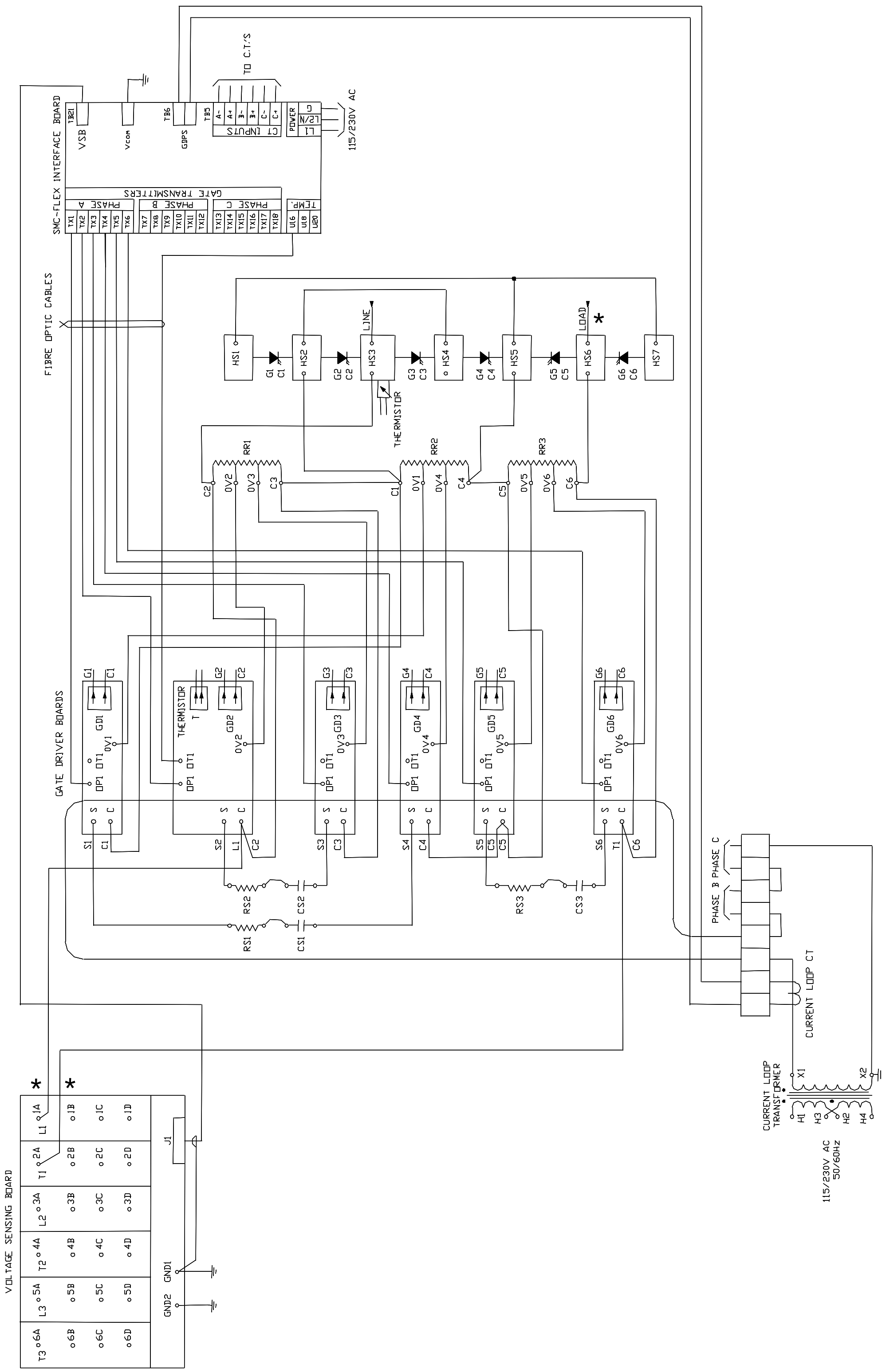
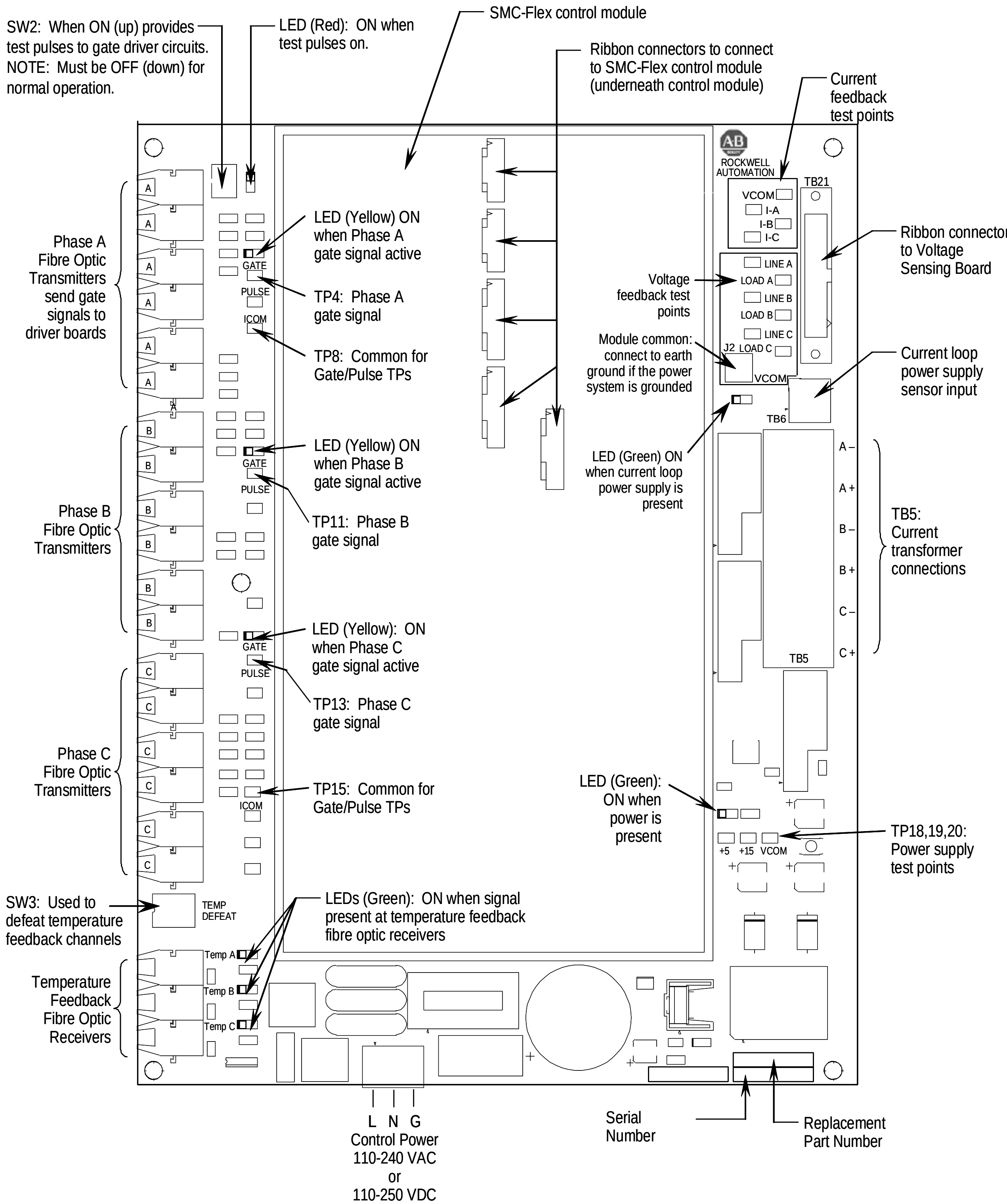


Figure 3.1 – Typical MV SMC-Flex Power System Wiring Diagram (5500/6900V shown)



Notes:
1. ICOM is the common connection for Gate and Pulse test points.
2. VCOM is the common connection for Current and Voltage feedback test points. If J2 (VCOM) is not connected to earth ground, **do not** connect ICOM and VCOM together, either directly or through test probes, meter or scope common.

Figure 3.2 – Connection and Test Information for Interface Board

Power Supply Tests

ATTENTION

Servicing energized industrial control equipment can be hazardous. Severe injury or death can result from electrical shock, burn, or unintended actuation of controlled equipment. Before proceeding, ensure that all sources of power are isolated and locked out. Verify that all circuits are voltage free using a hot stick or appropriate voltage measuring device. Any covers or barriers removed during this procedure must be replaced and securely fastened before energizing equipment. Where appropriate, the case of test equipment should be connected to ground.

1. Isolate incoming power
2. Open the door(s) providing access to the SCR/heatsink assemblies. You will be touching components which are connected to the high voltage power circuit, so be sure to isolate power as stated above.
3. Apply rated control voltage to the control circuits from a separate control source, or by plugging into the test source connector, and selecting the **TEST** position of the control switch.
4. Current loop – Check for 40 +5/-2 A.
5. Locate the SMC-Flex Interface board in the control section (See Figures 3.2 and 3.3). This circuit board has the control module mounted on it. Locate the switch labeled **SW2** at the upper left corner of the board. Close the switch by sliding the toggle up. This starts a pulse generator to supply simulated gate-pulse signals via fibre optic cables to the gate driver boards. A red LED beside the switch, and the three yellow LEDs on the left side of the Interface board should be lit. (**Note:** They may appear dim, depending on ambient light conditions).

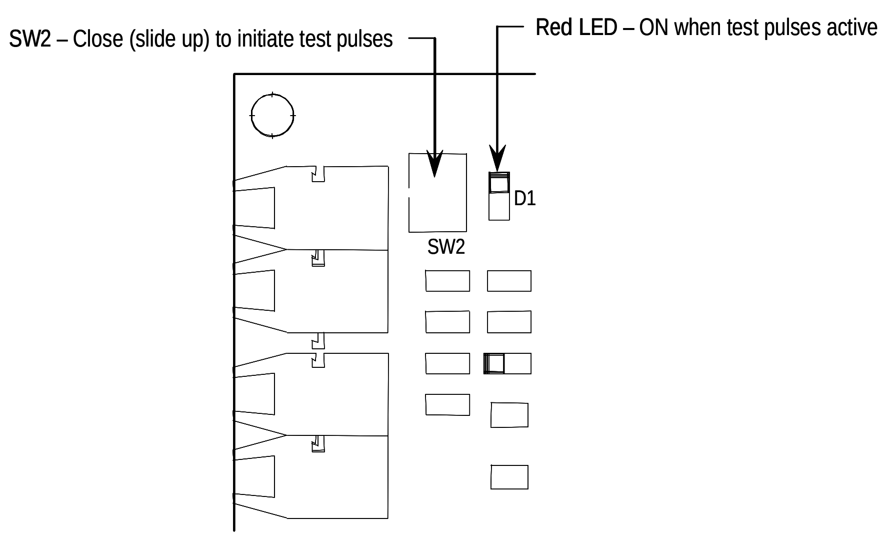


Figure 3.3 – Interface PCB

Power Supply Tests (cont.)

6. Since the gate driver circuits normally receive power from the snubber circuits when the SMC is operating, an alternate source must be used for testing. Locate the Portable Test Power Supply that was included with the equipment, and verify that the rating corresponds to the available power system (i.e. 110/120 VAC or 220/240 VAC). Plug the unit into the power source, and plug the green connector into **J1** on each of the gate driver boards (See Figure 3.4).

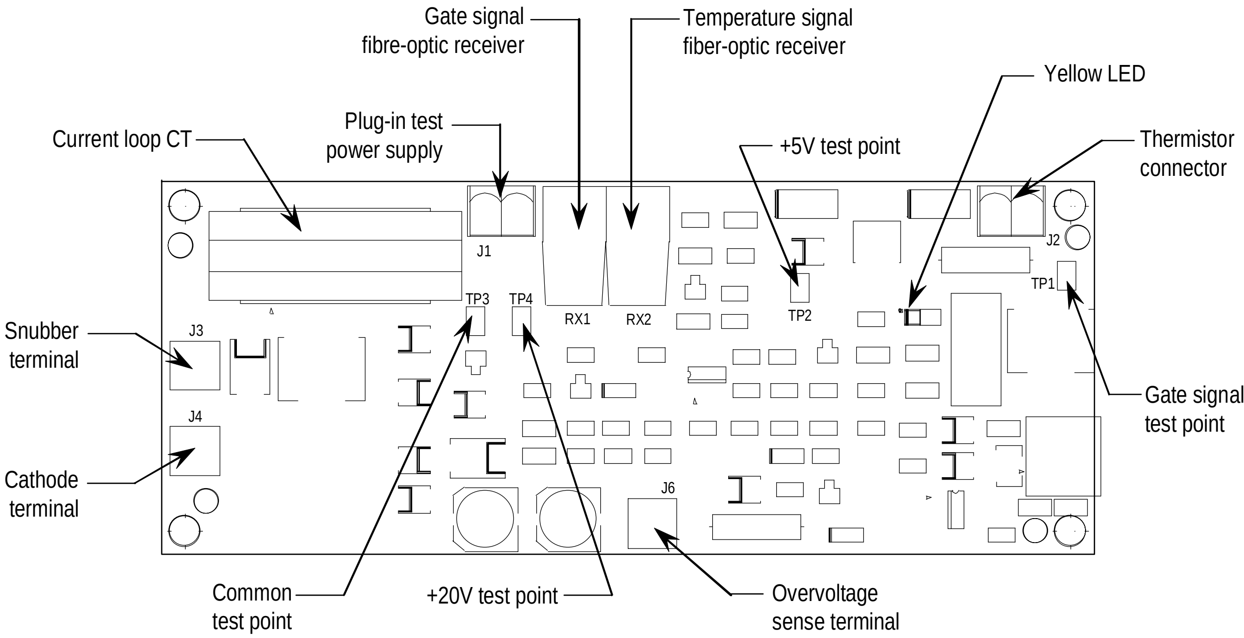


Figure 3.4 – Test Power Application on Gate Driver Board

7. The yellow LED on the upper right-hand side of the energized gate driver circuit should be lit (it may appear dim, depending on ambient light conditions). This is normally sufficient to verify that the gate drive system is functioning, however, a more detailed check can be made utilizing steps 8 and 9.

8. The gate-driver board voltage may be checked by connecting a DC voltmeter to **TP4 (+)** and **TP3 (-)** (see Figure 3.4). With the specified portable test power supply connected, the voltage should be 9 to 12 VDC. If the current loop is energized and the gate test pulses are **not** activated, the voltage should be 18 to 22 VDC.

9. The actual gate pulse may be checked by connecting an oscilloscope between **TP1** and **TP3** (see Figure 3.4). The pulse should appear as shown in Figures 3.5 and 3.6.

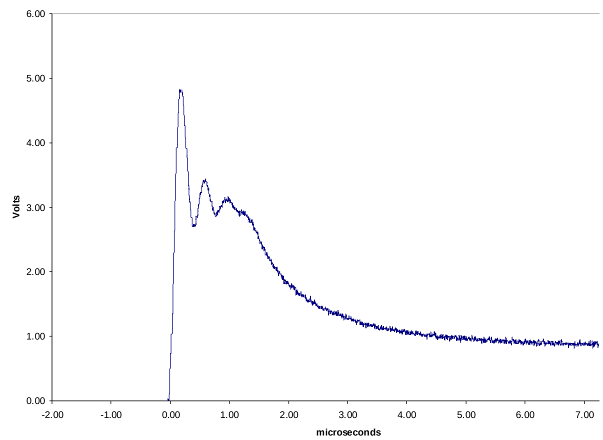


Figure 3.5 – Gate Pulse Detail – Typical SCR (ABB)

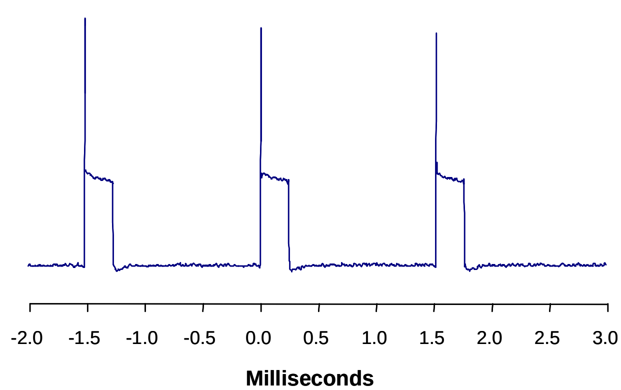


Figure 3.6 – Gate Pulse Test Waveform

10. If no pulse is observed, and the yellow LED is lit, check for a shorted gate on the SCR by removing the green plug and connecting an ohmmeter to the gate leads. If the LED is not lit, and the circuit voltage is as specified in step 8 (above), pinch the tab on the blue fibre-optic connector and carefully pull it straight out of the receiver. The end of the connector should glow red to indicate the presence of a gate signal.

If it does not, remove the other end of the cable from the interface board and check that the grey transmitter is emitting red light. If it is, the fibre-optic cable must be replaced. If it isn't, the interface board should be replaced.

11. When each gate driver circuit has been checked, disconnect the power supply and remove it from the cabinet.

ATTENTION

The gate-drive circuits operate at high voltage when the SMC is energized. Failure to remove the portable test power supply will result in equipment damage and may cause severe injury or death.

12. Open the switch **SW2** on the interface board (see Figure 3.3) before returning the unit to service. Ensure the red LED is off.

ATTENTION

If the **SW2** switch is not in the open position when the SMC is energized, the motor will start in an uncontrolled manner and may cause severe damage.

13. Check that all plugs and connectors are secure. Retrieve all hardware and tools from the equipment. Replace and secure any barriers removed during servicing and close all doors before applying power.

Control Function Tests

ATTENTION

Servicing energized industrial control equipment can be hazardous. Severe injury or death can result from electrical shock, burn, or unintended actuation of controlled equipment. Recommended practice is to disconnect and lock out control equipment from power sources, and allow any stored energy in capacitors to dissipate. The safety related work practices of NFPA 70E, Electrical Safety Requirements for Employee Workplaces, must be followed if it is necessary to work in the vicinity of energized equipment.

1. Apply rated control voltage to the control circuit.

2. Using the control schematic, apply control signals to cause relays and contactors to energize, to verify operation.

3. Remove any jumpers used in the test and restore all circuits to normal when finished.

Resistance Checks

To ensure that resistors and connections have not been damaged during shipment and installation, the following resistance tests should be performed before energizing the starter.

1. Remove all power from the equipment.

ATTENTION

Verify that all circuits are voltage free using a hot stick or appropriate voltage measuring device. Severe injury or death can result from electrical shock, burn, or unintended actuation of controlled equipment.

2. Measure DC resistance per the following chart:

Table 3.A – Power Circuit Resistance Measurements

Location of Probes	1000 V	1300 V	1500 V	2300 V	3300 V	4160 V	5500 V	6900 V
Cathode to Cathode (KOhms) ❶	–	–	–	–	22-30	23-31	21-29	24-32
Cathode to Cathode (KOhms) ❷	17-23	19-25	20-27	21-29	40-53	43-57	60-80 ❸	64-84 ❸
Cathode to Gate (Ohms)	10-40	10-40	10-40	10-40	10-40	10-40	10-40	10-40

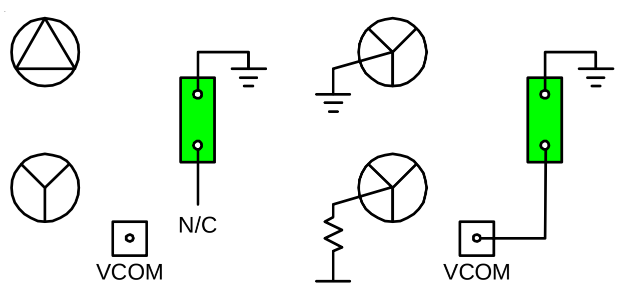
❶ Measured between terminals “Cathode” on CLGD Boards, upper two or bottom two within a phase.
❷ Measured between terminals “Cathode” on CLGD Boards, top to bottom within a phase.
❸ Measured between line and load terminals within a phase.

3. If abnormal readings are obtained, refer to Power Circuit Trouble-shooting on page 9-12.

Verify System Grounding

ATTENTION

Verify that the Neutral connection on the Interface board matches your power system grounding scheme. If the power system is truly ungrounded, the VCOM connection on the Interface board must **not** be connected. If the power system is grounded (solid, resistance, zig-zag, etc.), the VCOM connection must be connected to the green terminal block on the control panel.



Refer to Figure 3.2 for the VCOM connection point on the interface board.

Figure 3.7 – System Grounding

Voltage Sensing Module

The voltage-sensing module consists of a voltage sensing board and mounting plate (refer to Figure 9.2). The voltage sensing board has six independent channels which convert voltages up to 10800 V (7.2 kV @ 1.5 pu) down to low voltage levels which can be used by the SMC-Flex control logic.

Table 3.B shows the input voltage ranges for each of the input terminals on the voltage-sensing module. This module has been designed to operate at a nominal input voltage of up to 7200 V with a continuous 40% overvoltage. The output voltages are scaled to provide close to 10 V peak for a 140% input voltage at the high end of each of the voltage ranges.

Each of the channels has four taps to provide a range of input voltages, and software will be used to scale the output to show the correct value on the SMC-Flex front panel display. (See Parameter #106 – MV Ratio)

Table 3.B – Input Voltage Ranges

Tap	Voltage Range	MV Ratio
D	800 – 1449 V	1020
C	1450 – 2499 V	390
B	2500 – 4799 V	165
A	4800 – 7200 V	105

The MV ratios shown above are nominal values and may be fine tuned to achieve better accuracy on the display of the SMC-Flex control module. While running the motor in bypass mode, compare the voltage displayed on the control module to a known accurate meter connected to the same source voltage as the motor the MV SMC-Flex is controlling. Parameter 106, MV Ratio, may be changed up or down to match the Flex display to the external meter. A small change in ratio can make a large change in the display, so 5 units at a time is recommended. Increasing the ratio will decrease the displayed voltage, and visa versa.

Start-Up

1. Remove any temporary jumpers or grounding devices used during commissioning.

2. Check that all tools are removed from the equipment. Any tools or hardware used or dropped during installation and commissioning must be retrieved and accounted for.

3. Check that all barriers or covers removed during installation or commissioning have been securely mounted.

4. Close and secure all doors, and verify function of all interlocks that prevent access to medium voltage compartments when the unit is energized.

5. The controller is ready to power the motor.

Programming

Overview

This chapter provides a basic understanding of the programming keypad built into the SMC-Flex controller. This chapter also describes programming the controller by modifying the parameters.

Note: This User Manual pertains to SMC-Flex control modules with version 4.xx firmware (or later).

Keypad Description

The keys found on the front of the SMC-Flex controller are described below.

Esc	Escape	Exit a menu, cancel a change to a parameter value, or acknowledge a fault/alarm.
Sel	Select	Select a digit, select a bit, or enter edit mode in a parameter screen.
▲ ▼	Up/Down Arrows	Scroll through options increase/decrease a value, or toggle a bit.
↵	Enter	Enter a menu, enter edit mode in a parameter screen, or save a change to a parameter value.

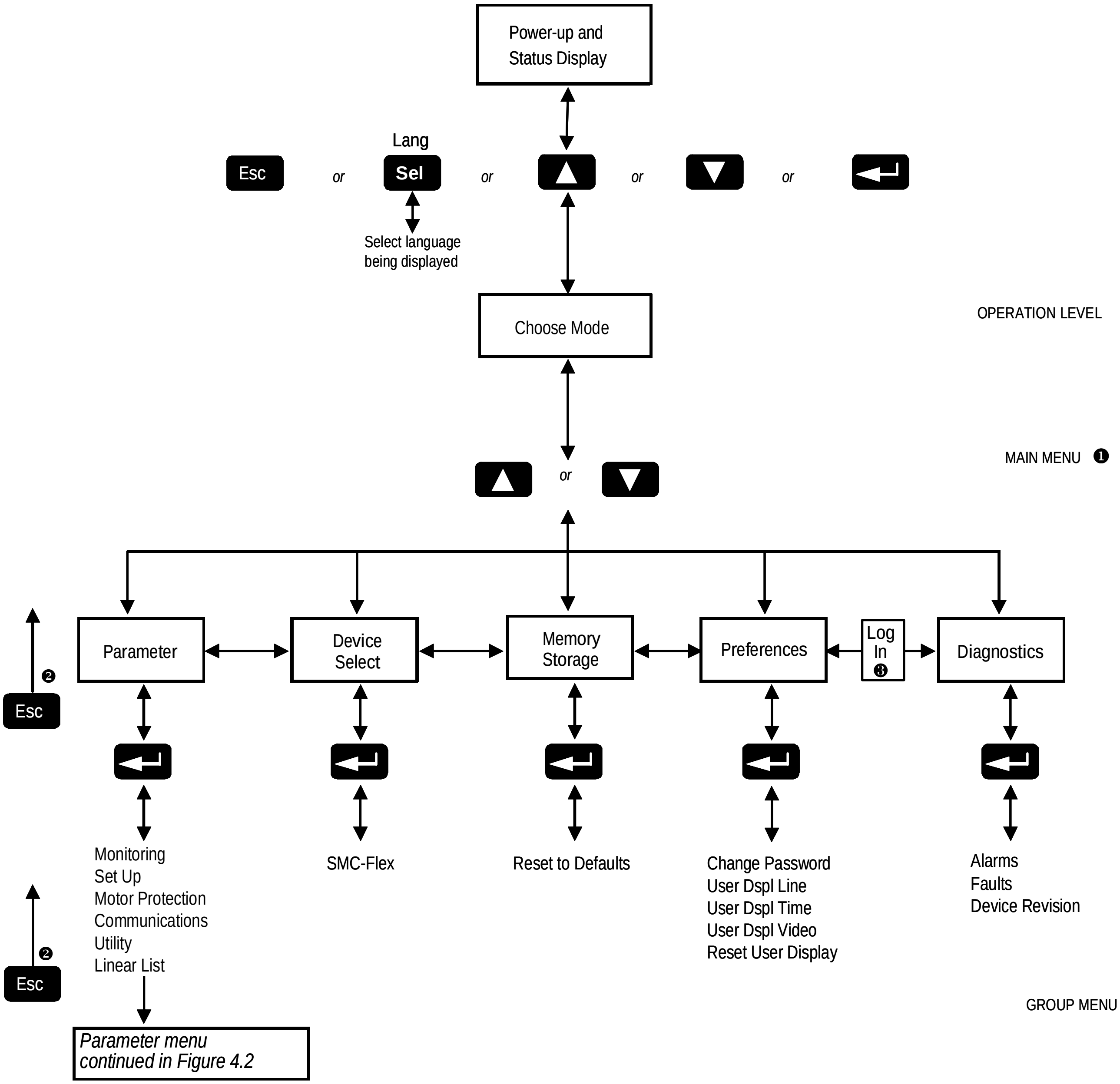
Note: For ease of programming values, after using the Enter key to edit, use the Sel key to jump to the digit that needs to be modified, then use the arrow keys to scroll through the digits.

Programming Menu

Parameters are organized in a three-level menu structure for straightforward programming. Figure 4.1 details the programming menu structure and the three-level hierarchy.

In order to change parameters, the controller must be in the STOP mode, and the control voltage must be present.

Programming Menu (cont.)

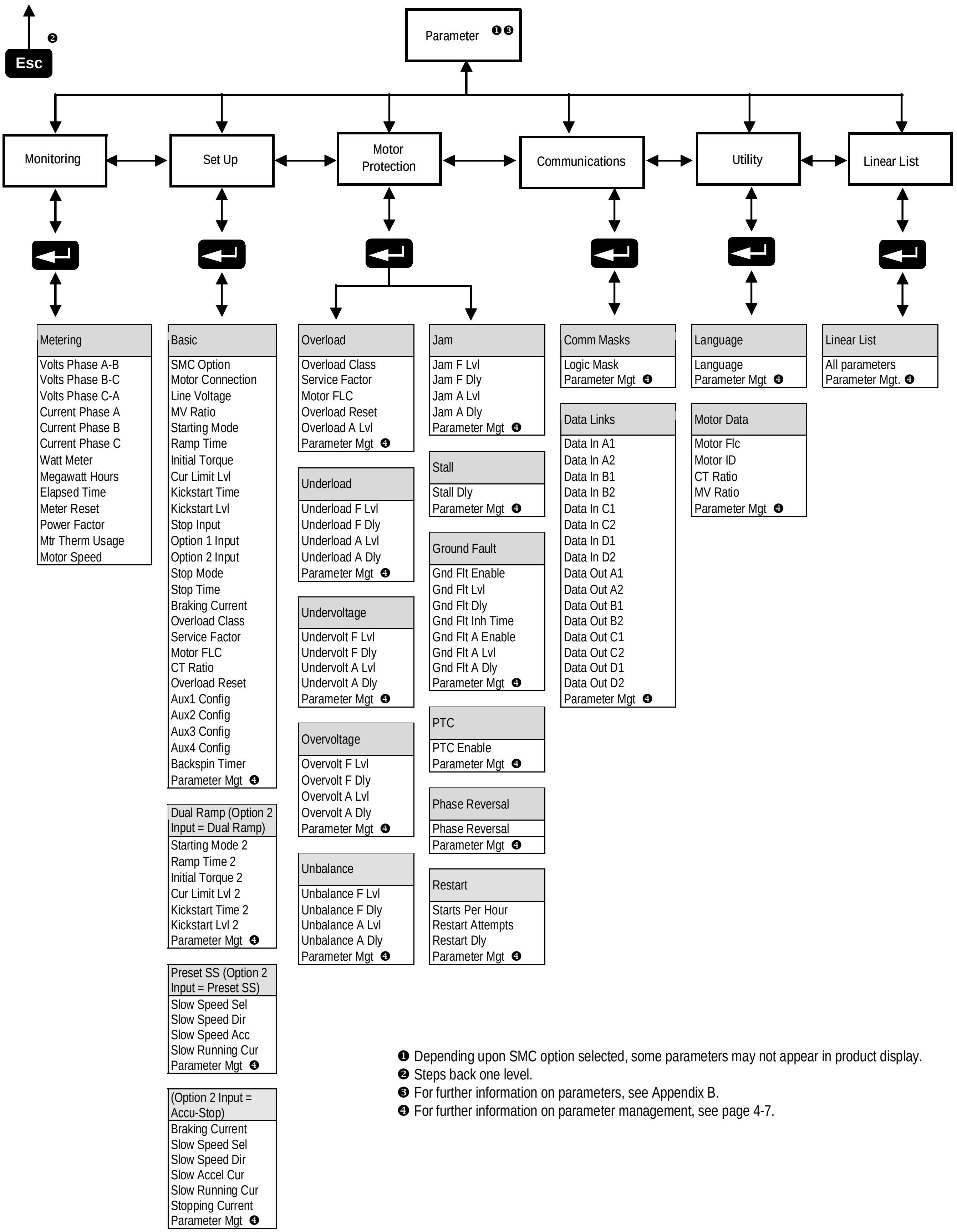


❶ The SMC-Flex controller does not support EEPROM, Link, Process or Start-up modes.

❷ Steps back one level.

❸ Shown if password protection is configured.

Figure 4.1 – Menu Structure Hierarchy



❶ Depending upon SMC option selected, some parameters may not appear in product display.
❷ Steps back one level.
❸ For further information on parameters, see Appendix B.
❹ For further information on parameter management, see page 4-7.

Figure 4.2 – Menu Structure Hierarchy

Programming Menu (cont.)

Table 4.A
Parameter Linear List

Parameter No.	Description	Parameter No.	Description	Parameter No.	Description
1	Volts Phase A-B	46	Motor FLC	91	Data In B2
2	Volts Phase B-C	47	Overload Reset	92	Data In C1
3	Volts Phase C-A	48	Factory Use	93	Data In C2
4	Current Phase A	49	Factory Use	94	Data In D1
5	Current Phase B	50	Overload A Lvl	95	Data In D2
6	Current Phase C	51	Underload F Lvl	96	Data Out A1
7	Watt Meter	52	Underload F Dly	97	Data Out A2
8	Kilowatt Hours	53	Underload A Lvl	98	Data Out B1
9	Elapsed Time	54	Underload A Dly	99	Data Out B2
10	Meter Reset	55	Undervolt F Lvl	100	Data Out C1
11	Power Factor	56	Undervolt F Dly	101	Data Out C2
12	Mtr Therm Usage	57	Undervolt A Lvl	102	Data Out D1
13	Motor Speed	58	Undervolt A Dly	103	Data Out D1
14	SMC Option	59	Overvolt F Lvl	104	Motor ID
15	Motor Connection	60	Overvolt F Dly	105	CT Ratio
16	Line Voltage	61	Overvolt A Lvl	106	MV Ratio
17	Starting Mode	62	Overvolt A Dly	107	Aux1 Config
18	Ramp Time	63	Unbalance F Lvl	108	Aux3 Config
19	Initial Torque	64	Unbalance F Dly	109	Aux4 Config
20	Cur Limit Level	65	Unbalance A Lvl	110	Aux2 Config
21	Reserved	66	Unbalance A Dly	111	Language
22	Kickstart Time	67	Jam F Lvl	112	Factory Use
23	Kickstart Level	68	Jam F Dly	113	Factory Use
24	Option 2 Input	69	Jam A Lvl	114	Factory Use
25	Starting Mode 2	70	Jam A Dly	115	Parameter Mgmt
26	Ramp Time 2	71	Stall Delay	116	Backspin Timer
27	Initial Torque 2	72	Gnd Flt Enable	117	Factory Use
28	Cur Limit Level 2	73	Gnd Flt Level	118	Factory Use
29	Reserved	74	Gnd Flt Delay	119	Factory Use
30	Kickstart Time 2	75	Gnd Flt Inh Time	120	Factory Use
31	Kickstart Level 2	76	Gnd Flt A Enable	121	Factory Use
32	Stop Mode	77	Gnd Flt A Lvl	122	Factory Use
33	Stop Time	78	Gnd Flt A Dly	123	Factory Use
34	Factory Use	79	PTC Enable	124	Fault 1
35	Braking Current	80	Phase Reversal	125	Fault 2
36	Factory Use	81	Starts Per Hour	126	Fault 3
37	Factory Use	82	Restart Attempts	127	Fault 4
38	Factory Use	83	Restart Delay	128	Fault 5
39	Slow Speed Sel	84	Factory Use	129	Factory Use
40	Slow Speed Cur	85	Factory Use	130	Factory Use
41	Slow Accel Cur	86	Factory Use	131	Factory Use
42	Slow Running Cur	87	Logic Mask	132	Option 1 Input
43	Stopping Current	88	Data In A1	133	Stop Input
44	Overload Class	89	Data In A2	134	Factory Use
45	Service Factor	90	Data In B1		

Password

The SMC-Flex Controller allows the user to limit access to the programming system through password protection. This feature is disabled with a factory-set default of 0. To modify the password or login after a password is programmed, complete the procedure below.

Description	Action	Display
–	–	0.0 Amps 0 Volt 0 %MTU
1. Press the ESC key to go from the status display to the Main menu.	Esc	Main Menu Diagnostics Parameter
2. Scroll with the Up/Down keys until the Preferences option is highlighted.	▲ ▼	Main Menu Preferences Diagnostics
3. Press the Enter key to access the Preferences menu.	↵	Preferences: Change Password User Dspy lines
4. Scroll with the Up/Down keys until the Change Password option is highlighted.	▲ ▼	Preferences: Change Password User Dspy lines
5. Press the Enter key.	↵	
6. Press the Up/Down keys to enter the desired number. If you are modifying the password, make a note of it as displayed.	▲ ▼	Prefs: Password New Code: 83 Verify: 83
7. Verification of the new password is required. Press the Enter key.	↵	
8. Press the Enter key after you have completed modifying the password. ❶	↵	Preferences: Change Password User Dspy lines

❶ To complete the programming process, re-enter the Main Menu mode to log out. This will eliminate unauthorized process to the programming system.

Note: If you lose or forget the password, contact your nearest Rockwell Automation sales office. You can also call Rockwell Automation Medium Voltage Product Support at **1-519-740-4790** for assistance.

Parameter Management

Before you begin programming, it is important to understand how the controller memory is:

- structured within the SMC-Flex controller
- used on power-up and during normal operation

Refer to Figure 4.3 and explanations below.

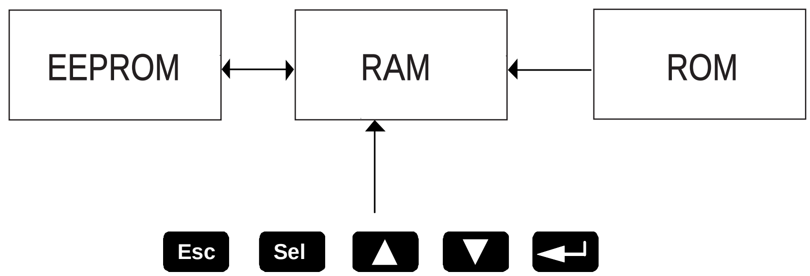


Figure 4.3 – Memory Block Diagram

Random Access Memory (RAM)

This is the work area of the controller after it is powered up. When you modify parameters in the Set Up mode, the new values are stored in RAM. When power is applied to the controller, parameter values stored in the EEPROM are copied to RAM. **RAM is volatile and the values stored in this area are lost when the controller is powered down.**

Read-only Memory (ROM)

The SMC-Flex controller comes with factory default parameter values. These settings are stored in nonvolatile ROM and are displayed the first time you enter the Program mode.

Electrically Erasable Programmable Read-only Memory (EEPROM)

The SMC-Flex controller provides a nonvolatile area for storing user-modified parameter values in the EEPROM.

Using Parameter Management with DPI HIM

Note: The SMC-Flex will automatically save any parameter changes made during the programming process.

Memory Storage and Parameter Management perform the same function of resetting to defaults.

Description	Action	Display
Recalling Defaults After parameter values have been modified, factory default settings can still be re-initialized.		

Parameter Modification

All parameters are modified using the same method. The basic steps to performing parameter modification are described below.

Notes:
1. Parameter values modified while the motor is operating are not valid until the next start sequence begins.
2. If the password is set, parameters cannot be adjusted without logging in.
3. Use the Sel key to highlight a single digit.

Description	Action	Display ❷
–	–	0.0 Amps 0 Volt 0 %MTU
1. Press the ESC key to go from the status display to the Main menu.	Esc	—
2. Scroll with the Up/Down keys until the Preferences option is highlighted.	▲ ▼	Main Menu Parameter Memory Storage
3. Press the Enter key to access the Parameter menu.	↵	F G P : File Monitoring Set Up
4. Scroll with the Up/Down keys until the option you want to use (Monitoring, Motor Protection, etc.) is highlighted. For this example, Set Up will be used.	▲ ▼	F G P : File Set Up Motor Protection
5. Press Enter to select the Set Up group.	↵	—
6. Scroll to Basic Set Up and press Enter. ❶	▲ ▼ ↵	F G P : Group Basic Set Up
7. Scroll to the Starting Mode parameter by using the Up/Down keys, and press Enter.	▲ ▼ ↵	F G P : Parameter Starting Mode Ramp Time
8. Press Enter to select the option. Scroll to the option of your choice by using the Up/Down keys. For this example, we will choose Current Limit.	▲ ▼ ↵	F G P : P# 17 Starting Mode Current Lim
9. Press the Enter key to accept the new setting.	↵	—
10. Scroll to the next parameter by using the Down key. Continue the process until all desired settings are entered.	▼	F G P : P# 18 Ramp Time 10 Secs

❶ The SMC Option advises the user if any control option (i.e., Pump Control) is resident. This parameter is factory set and cannot be modified by the user.

❷ The display will indicate that the second line is now active by highlighting the first character. If the LCD display does not provide a highlighted cursor, then the controller is in the Display mode.

Soft Start

The following parameters are specifically used to adjust the voltage ramp supplied to the motor.

Parameter	Option
Starting Mode This must be programmed for Soft Start.	Soft Start
Ramp Time ❶ This programs the time period that the controller will ramp the output voltage up to full voltage from the initial Torque level programmed.	0 to 30 s
Initial Torque The initial reduced output voltage level for the voltage ramp to the motor is established and adjusted with this parameter.	0 to 90% locked rotor torque
Kickstart Time A boost of current is provided to the motor for the programmed time period.	0.0 to 2.0 s
Kickstart Level Adjusts the amount of current applied to the motor during the kickstart time.	0 to 90/% locked rotor torque

❶ If the controller senses that the motor has reached full speed before completing the Soft Start, it will automatically switch to providing full voltage to the motor.

Current Limit Start

To apply a fixed, reduced-output voltage to the motor, the following parameters are provided for user adjustment:

Parameter	Option
Starting Mode This must be programmed for Current Limit.	Current Limit
Ramp Time ❶ This programs the time period that the controller will hold the fixed, reduced output voltage before switching to full voltage.	0 to 30 s
Current Limit Level This parameter provides adjustability for the reduced output voltage level provided to the motor.	50 to 600% full load current
Kickstart Time A boost of current is provided to the motor for the programmed time period.	0.0 to 2.0 s
Kickstart Level Adjusts the amount of current applied to the motor during the kickstart time.	0 to 90/% locked rotor torque

❶ If the controller senses that the motor has reached full speed before completing the Current Limit Start, it will automatically switch to providing full voltage to the motor.

Dual Ramp Start

The SMC-Flex controller provides the user with the ability to select between two Start settings. The parameters below are available in the Set Up programming mode. To obtain Dual Ramp control, Ramp #1 is located in the Basic Set Up and Ramp #2 is located in the Option 2 Input (Dual Ramp).

Parameter	Option
Set Up The user must select the Set Up programming mode to obtain access to the Dual Ramp parameters.	—
Basic Set Up/Starting Mode Set up as stated in previous pages.	—
Option 1 Input (Dual Ramp) ❶ This allows the user the option to choose between two Soft Start profiles defined by: 1. Start Mode/Ramp Time/Initial Torque and 2. Start Mode 2/Ramp Time 2/Initial Torque 2. When this feature is turned on, the ramp time/initial torque combination is determined by a hard contact input to terminal 15. When this input signal is low, ramp time/initial torque 2 are selected. Once the Option 2 Input has been set to Dual Ramp, you must ESC back to the Parameter (File) menu. Re-enter into the Set Up menu to show both Basic Set Up and Dual Ramp.	—
Basic Set Up/Start Mode ❷ This selects the start mode for option #1.	—
Basic Set Up/Ramp Time This programs the time period during which the controller will ramp the output voltage up to full voltage for the first Start setup.	0 to 30 s
Basic Set Up/Initial Torque This parameter establishes and adjusts the initial reduced output voltage level for the first Soft Start setup.	0 to 90/% locked rotor torque
Dual Ramp/Start Mode 2 ❷ This selects the start mode for option #2.	—
Dual Ramp/Ramp Time 2 This programs the time period during which the controller will ramp the output voltage up to full voltage for the second Start setup.	0 to 30 s
Dual Ramp/Initial Torque 2 The initial reduced output voltage level for the second Start setup is established and adjusted with this parameter.	0 to 90/% locked rotor torque

❶ The Dual Ramp feature is available on the standard controller.

❷ Kickstart can be programmed for both start modes.

Full Voltage Start

The SMC-Flex controller may be programmed to provide a full voltage start (output voltage to the motor reaches full voltage within 1/4 second) with the following programming:

Parameter	Option
Starting Mode This **must** be programmed for Full Voltage.	Full Voltage

Linear Speed

The SMC-Flex provides the user the ability to control the motor speed during starting and stopping maneuvers. A tach input is required as specified in *Linear Speed Acceleration* on page 1-7.

Parameter	Option
Starting Mode This **must** be programmed for Linear Speed.	Linear Speed
Ramp Time This programs the time period that the controller will ramp from 0 speed to full voltage.	0 to 30 s
Kickstart Time A boost of current is provided to the motor for the programmed time period.	0.0 to 2.2 s
Kickstart Level Adjusts the amount of current applied to the motor during the kickstart time.	0 to 90/% locked rotor torque

Stop Control

The SMC-Flex can be programmed to extend the motor stop time beyond the normal coast-to-rest time. There are two standard stop modes: Soft Stop and Linear Speed Deceleration.

Parameter		Option
Stopping Mode	This may be set to one of two standard choices. ❶	Soft Stop Linear Speed ❷
Stop Time	Allows the user to set the time period for the stopping function.	0 to 120 s ❸

❶ Refer to Chapter 6 for optional stop control modes.

❷ A motor tachometer is required (refer to page 1-7).

❸ Consult factory if settings over 30 seconds are required. The base rating of the MV SMC-Flex is two starts (or one start/stop combination) per hour, thirty seconds maximum for each operation. A stopping operation counts as a start for purposes of thermal capacity calculations.

Note: Options that control the stopping of the motor (Soft Stop, Pump Stop, Linear Speed, Braking) require the self-powered gate drivers to be pre-charged by the current loop power supply. If this supply is not present, an alarm symbol will appear at the upper right corner of the control module display, and the options will be inhibited. When the motor is stopped, it will coast. If the supply is restored, the alarm symbol will be cleared and the module will perform the programmed sequence.

Preset Slow Speed

This control mode may be configured to allow slow speed operation of the motor.

Parameter		Option
Slow Speed Select	Allows the user to program the slow speed that best fits the application.	Low: 7% – Forward 10% – Reverse High: 15% – Forward 20% – Reverse
Slow Speed Direction	This parameter programs the slow speed motor rotational direction.	Forward, Reverse
Slow Accel Current	Allows the user to program the required current to accelerate the motor to slow speed operation.	0 to 450% of full load current
Slow Running Current	Allows the user to program the required current to operate the motor at the slow speed setting.	0 to 450% of full load current

Basic Setup

The Basic Setup programming group provides a limited parameter set, allowing quick start-up with minimal adjustments. If the user is planning to implement some of the advanced features (i.e., Dual Ramp, Unbalance Level, etc.), then the Linear List programming group should be selected. It provides all the Basic Setup parameter set plus the advanced set.

Parameter	Option
SMC Option Displays the type of controller. This is factory set and not adjustable.	Standard
Motor Connection Displays the location of the SMC in relation to the motor windings.	Line or Delta ❸
Line Voltage Displays the system line voltage the unit is connected to.	—
MV Ratio Scales the output from the Voltage Sensing Board to display correct line voltage.	1 to 10000 (See Table 3.B – Input Voltage Ranges)
Starting Mode Allows the user to program the SMC-Flex controller for the type of starting that best fits the application.	Soft Start, Current Limit, Full Voltage, Linear Speed
Ramp Time This sets the time period during which the controller will ramp the output voltage.	0 to 30 s
Initial Torque ❶ The initial reduced voltage output level for the voltage ramp is established and adjusted with this parameter.	0 to 90/% locked rotor torque
Current Limit Level ❷ The current limit level that is applied for the Ramp time selected.	50 to 600% FLC

❶ Starting Mode must be programmed to Soft Start to obtain access to the Initial Torque parameter.

❷ Starting Mode must be programmed to Current Limit to obtain access to the Current Limit Level parameter.

❸ This is not to indicate how the motor windings are configured. Do not select "Delta" for MV applications.

Parameter	Option
Kickstart Time A boost current is provided to the motor for the programmed time period.	0.0 to 2.0 s
Kickstart Level Adjusts the amount of current applied to the motor during kickstart.	0 to 90% of locked rotor torque
Stop Input Allows the user to select the operation of terminal 18, Stop Input.	Coast, Stop Option
Option 1 Input Allows the user to select the operation of terminal 16, Option Input #1.	Disable, Coast, Stop Option, Fault, Fault NC, Network
Option 2 Input Allows the user to select the operation of terminal 15, Option Input #2.	Disable, Slow Speed, Dual Ramp, Fault, Fault NC, Network, Clear Fault, Emergency Run ❹
Stop Mode Allows the user to program the SMC-Flex controller for the type of stopping that best fits the application.	Disable, Soft Stop, Linear Speed
Stop Time This sets the time period which the controller will ramp the voltage during a stopping maneuver .	0.0 to 120 s
CT Ratio Scales the CT input to actual motor current (5 amp secondary assumed).	1 to 1500
Aux1 Config Contact is provided as standard with the SMC-Flex controller. This contact is located at terminals 19 and 20. Aux Contacts 1 allows the user to configure the operation of the contacts.	Normal, Up-to-speed, Fault, Alarm, Network Control, External Bypass: (N.O./N.C.)
Aux2 Config Contact is provided as standard with the SMC-Flex controller. This contact is located at terminals 29 and 30. Aux Contacts 2 allows the user to configure the operation of the contacts.	Normal, Up-to-speed, Fault, Alarm, Network Control, External Bypass: (N.O./N.C.)
Aux3 Config Contact is provided as standard with the SMC-Flex controller. This contact is located at terminals 31 and 32. Aux Contacts 3 allows the user to configure the operation of the contacts.	Normal, Up-to-speed, Fault, Alarm, Network Control, External Bypass: (N.O./N.C.)
Aux4 Config Contact is provided as standard with the SMC-Flex controller. This contact is located at terminals 33 and 34. Aux Contacts 4 allows the user to configure the operation of the contacts.	Normal, Up-to-speed, Fault, Alarm, Network Control, External Bypass: (N.O./N.C.)
Parameter Mgmt Recall of factory default parameter values.	Ready, Load Default

❹ When programmed for 'Emergency Run' and the Option 2 input is energized, a 'Start' command will first close the bypass contactor, then the line contactor for an across-the-line start of the motor. A 'Stop' command will open the line contactor first and allow the motor to coast, regardless of the programmed 'Stop Mode'. For Pump Option modules, the Option 2 input defaults to 'Emergency Run' for MV applications.

Motor Protection

While the Basic Set Up group allows the user to get started with a minimum number of parameters to modify, the Motor Protection group allows full access to the SMC-Flex controller's powerful parameter set. Following is a listing of the additional setup parameters provided.

Note: The majority of parameters have a Fault and an Alarm setting.

Parameter	Option
Overload Allows the user to select the operation of the overload.	Trip Class, Service Factor, Motor FLC, Overload Reset, Overload Alarm Level
Underload ❷ Determines the trip level as a percentage of the motor's FLA, and the delay period.	Underload Fault Level, Underload Fault Delay, Underload Alarm Level, Underload Alarm Delay
Undervoltage ❶ Determines the trip level as a percentage of line voltage and delay period.	Undervoltage Fault Level, Undervoltage Fault Delay, Undervoltage Alarm Level, Undervoltage Alarm Delay
Overvoltage ❶ Determines the trip level as a percentage of line voltage and delay period.	Overvoltage Fault Level, Overvoltage Fault Delay, Overvoltage Alarm Level, Overvoltage Alarm Delay
Unbalance ❶ Allows the user to set the current unbalance trip level and delay period.	Unbalance Fault Level, Unbalance Fault Delay, Unbalance Alarm Level, Unbalance Alarm Delay
Jam ❷ Determines the trip level as a percentage of motor full load current and delay period.	Jam Fault Level, Jam Fault Delay, Jam Alarm Level, Jam Alarm Delay
Stall Allows the user to set the stall delay time.	Stall Delay
Ground Fault ❸ Allows the user to enable the ground fault level in amps, delay time and inhibit time. A separate core balance current transformer is required.	Ground Fault Enable, Ground Fault Level, Ground Fault Delay, Ground Fault Inhibit Time, Ground Fault Alarm Enable, Ground Fault Alarm Level, Ground Fault Alarm Delay
PTC ❹ Allows the user to connect a PTC to the SMC and enable a fault when it becomes active.	PTC Enable
Phase Reversal Determines the proper orientation of line connections to the SMC. If Enabled and phases are out of sequence, a fault will be indicated.	Phase Reversal
Restarts Allows the user to determine the maximum number of restarts per hour the unit can experience, and delay time between consecutive starts.	Restarts Per Hour, Restart Attempts, Restart Delay

❶ The delay time must be set to a value greater than zero when Undervoltage, Overvoltage and Unbalance are enabled.

❷ For Jam and Underload detection to function, the Motor FLC must be programmed in the Motor Protection group. See page 4-16.

❸ See details in *Ground Fault* on page 1-12.

❹ See details in *Thermistor/PTC Protection* on page 1-13.

Example Settings

Undervoltage ❶

With Line Voltage programmed for 4160 V and the Undervoltage level programmed for 80%, the trip value is 3328 V.

Overvoltage ❶

With Line Voltage programmed for 3300 V and the Overvoltage level programmed for 115%, the trip value is 3795 V.

Jam ❷❸

With Motor FLC programmed for 150 Amps and the Jam level programmed for 400%, the trip value is 600 Amps.

Underload ❷

With Motor FLC programmed for 90 Amps and the Underload level programmed for 60%, the trip value is 54 Amps.

❶ The average value of the three phase-to-phase voltages is utilized.
❷ The largest value of the three phase currents is utilized.
❸ The SMC-Flex will self-protect.

Motor Information

The Basic Set Up and Overload programming group allows the user to set parameters indicating to the controller which motor is connected. It is important to correctly input the data to achieve the best performance from your controller.

ATTENTION

For overload protection, it is critical that the data be entered as it appears on the motor nameplate.

Motor Data Entry

In the Program mode, enter the correct values into the Overload group:

Description	Option	Display
Overload Class ❷❸ The factor default setting disables overload protection. To enable it, enter the desired trip class in this parameter.	Disable, 10, 15, 20, 30	F G P : P# 44 Overload Class Class ##
Service Factor ❷❸ Enter the value from the motor's nameplate.	0.01 to 1.99	F G P : P# 45 Service Factor #.##
Motor FLC ❶❷❸ Enter the value from the motor's nameplate.	1.0 to 2200A	F G P : P# 46 Motor FLC ###.# Amps
Overload Reset ❷❸ Allows the user to select either a manual or auto reset after an overload.	Manual, Auto	F G P : P# 47 Overload Reset Manual
Motor Connection ❸ ❹ Enter the type of motor being connected to the SMC-Flex: Line or Delta	Line, Delta	F G P : P# 15 Motor Connection Line
Line Voltage ❶❸ Enter the system voltage in this parameter. This **must** be done to ensure optimum motor performance and correct operation of undervoltage and overvoltage protection.	1 to 10,000 V	F G P : P# 16 Line Voltage ### Volt

❶ Refer to the SMC-Flex controller nameplate for maximum ratings. Exceeding these could result in damage to the controller.

❷ Found in Overload programming group. Only one location needs to be programmed.

❸ Found in Basic Set Up programming group.

❹ This is not to indicate how the motor windings are configured. Do not select "Delta" for MV applications.

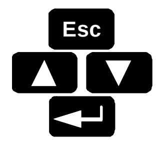
Metering

Overview

While the SMC-Flex controller operates your motor, it also monitors several different parameters, providing a full function metering❶ package.

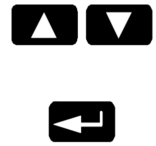
Viewing Metering Data

To access the metering information, follow the procedure below:

Description	Action	Display
–	–	##.# Amps ### Volt ## %MTU
1. Press any key to access the Main menu.		Main Menu Parameter Memory Storage
2. Scroll with the Up/Down keys until the Parameter option is shown.		Main Menu Parameter Memory Storage
3. Press the Enter key to access the Parameter option.		—
4. Scroll with the Up/Down keys until the Monitoring option is displayed.		F G P : File Monitoring Set Up
5. Press the Enter key to access the Monitoring group.		—
6. Press the Enter key to access the Metering group.		F G P : Group Metering

❶ Refer to *Metering* on page 1-16 or Figure 4.2 on page 4-3 for details on the metering functions .

Viewing Metering Data (cont.)

Description	Action	Display
7. Scroll through the Metering parameters with the Up/Down keys to access the desired information. Press the Enter key to view that parameter.		F G P : P# 1 Volts Phase A-B ### Volt F G P : P# 2 Volts Phase B-C ### Volt F G P : P# 3 Volts Phase C-A ### Volt F G P : P# 4 Current Phase A ##.# Amps F G P : P# 5 Current Phase B ##.# Amps F G P : P# 6 Current Phase C ##.# Amps F G P : P# 7 Watt Meter ##.# KW F G P : P# 8 Kilowatt Hours ##.# KWH F G P : P# 9 Elapsed Time ##.# Hour F G P : P# 10 Meter Reset No F G P : P# 11 Power Factor ##.# F G P : P# 12 Mtr Therm Usage ## %MTU

The metering values that are displayed on the SMC-Flex can be modified to show you desired values by accessing Main Menu / Preferences.

Options

Overview

The SMC-Flex controller offers a variety of unique control programming and communication options that provide enhanced capabilities. (See Chapter 1 for brief descriptions of each option.)

Note: Only one option can reside in a controller.

Human Interface Module

The control buttons available with the Bulletin 20-HIM Human interface modules are compatible with the SMC-Flex controller's control options. The following table details the functionality of each button with regards to each option.

Notes: (1) The logic mask port must be enabled prior to initiating control commands to the SMC-Flex controller. Refer to *Control Enable* on page 2-16 for instructions.
(2) The control terminals must be wired according to Figure 3.10 on page 3-10 and Figure 3.16 on page 3-16.

Option	Action	Operation
Standard		
Soft Stop Current Limit Full Voltage Linear Speed	I	The green start button, when pressed, will commence motor acceleration to full speed.
	O	The red stop button, when pressed, will provide a coast stop, and/or reset a fault.
	Jog	The jog button, when pressed, will initiate the programmed maneuver.
Preset Slow Speed	I	The green start button, when pressed, will commence motor acceleration to full speed.
	O	The red stop button, when pressed, will provide a coast stop.
	Jog	The jog button is not active for Preset Slow Speed. * Slow Speed cannot be operated via the HIM.

Human Interface Module (cont.)

Option	Action	Operation
Pump Control		
Pump Control	I	The green start button, when pressed, will commence motor acceleration to full speed.
	O	The red stop button, when pressed, will provide a coast stop, and/or reset a fault.
	Jog	The jog button, when pressed, will initiate a pump stop maneuver.
Braking Control ❶		
Smart Motor Braking	I	The green start button, when pressed, will commence motor acceleration to full speed.
	O	The red stop button, when pressed, will provide a coast stop, and/or reset a fault.
	Jog	The jog button, when pressed, will initiate a brake stop.
Accu-Stop	I	The green start button, when pressed, will commence motor acceleration to full speed.
	O	The red stop button, when pressed, will provide a coast stop, and/or reset a fault.
	Jog	With a "stopped" status, the jog button, when pressed, will initiate slow speed motor operation. From an "at speed" condition, the jog button, when pressed, will initiate braking to slow speed operation. The controller will maintain slow speed operation as long as the jog button is pressed.
Slow Speed with Braking	I	The green start button, when pressed, will commence motor acceleration to full speed.
	O	The red stop button, when pressed, will provide a coast stop, and/or reset a fault.
	Jog	The jog button will initiate a brake stop. * Slow Speed cannot be operated via the HIM.

❶ Braking Control is not offered for standard use in MV applications. Please consult factory for further assistance.

ATTENTION

The Bulletin 20-HIM interface module's stop push button is not intended to be used as an emergency stop. Refer to the applicable standards for emergency stop requirements.

Programming Parameters

The following table provides the option-specific parameters that are provided with each control option. These parameters are in addition to those already discussed in the Basic Set Up and Metering groups. Diagrams supporting the options described below are shown later in this chapter.

Option	Parameter	Range
Pump Control		
Pump Control	SMC Option This parameter identifies the type of control present and is not user programmable.	Pump Control
	Pump Stop Time Allows the user to set the time period for the pump stopping function.	0 to120 s
	Starting Mode Allows the user to program the SMC-Flex controller for the type of starting that best fits the application.	Pump Start, Soft Start, Current Limit Start, Full Voltage
Braking Control ❷		
SMB Smart Motor Braking	SMC Option This parameter identifies the type of control present and is not user programmable.	Braking Control
	Braking Current ❶ Allows the user to program the intensity of the braking current applied to the motor.	0…400% of full load current

❶ All braking/stopping current settings in the range of 1…100% will provide 100% braking current to the motor.

❷ Braking Control is not offered for standard use in MV applications. Please consult factory for further assistance.

Programming Parameters (cont.)

Option	Parameter	Range
Braking Control ❷ (cont.)		
Accu-Stop	SMC Option This parameter identifies the type of control present and is not user programmable.	Braking Control
	Slow Speed Select Allows the user to program the slow speed that best fits the application.	Low: 7% High: 15%
	Slow Accel Current Allows the user to program the required current to accelerate the motor to slow speed operation.	0 to 450% of full load current
	Slow Running Current Allows the user to program the required current to operate the motor at slow speed operation.	0 to 400% of full load current
	Braking Current ❶ Allows the user to program the intensity of the braking current applied to the motor.	0 to 400% of full load current
	Stopping Current ❶ Allows the user to program the intensity of the braking current applied to the motor from slow speed operation.	0 to 400% of full load current
Slow Speed with Braking	SMC Option This parameter identifies the type of control present and is not user programmable.	Braking Control
	Slow Speed Select Allows the user to program the slow speed that best fits the application.	Low: 7% High: 15%
	Slow Accel Current Allows the user to program the required current to accelerate the motor to slow speed operation.	0 to 450% of full load current
	Slow Running Current Allows the user to program the required current to operate the motor at the slow speed setting.	0 to 450% of full load current
	Braking Current ❶ Allows the user to program the intensity of the braking current applied to the motor.	0 to 400% of full load current

❶ All braking/stopping current settings in the range of 1…100% will provide 100% braking current to the motor.

❷ Braking Control is not offered for standard use in MV applications. Please consult factory for further assistance.

Note: Options that control the stopping of the motor (Soft Stop, Pump Stop, Linear Speed, Braking) require the self-powered gate drivers to be pre-charged by the current loop power supply. If this supply is not present, an alarm symbol will appear at the upper right corner of the control module display, and the options will be inhibited. When the motor is stopped, it will coast. If the supply is restored, the alarm symbol will be cleared and the module will perform the programmed sequence.

Control Wiring

Refer to Chapter 1 – Product Overview for typical control wiring examples used with various control schemes.

Diagnostics

Overview

This chapter describes the fault diagnostics of the MV SMC-Flex controller. Further, this section describes the conditions that cause various faults to occur.

Protection Programming

Many of the protective features available with the SMC-Flex controller can be enabled and adjusted through the programming parameters provided. For further details on programming, refer to the Motor Protection section in Chapter 4, *Programming.*

Fault Display

The SMC-Flex controller comes equipped with a built-in three-line, 16-character LCD. The LCD displays the fault message on the first line, the fault code on the second line, and the fault description on the third line.

```
Faulted
Fault #27
COMS LOSS P2
```

Figure 7.1 – Fault Display

Note: The fault display will remain active as long as control power is applied. If control power is cycled, the fault will be cleared, the controller will re-initialize, and the display will show a status of "Stopped".

Note: You can hit ESC to get to another programming/diagnostic list, but the SMC-Flex will still be in a faulted state.

Important: Resetting a fault will not correct the cause of the fault condition. Corrective action must be taken before resetting the fault.

Clear Fault

You can clear a fault using any of several methods:

- Program the SMC-Flex controller for a Clear Fault, which can be found in Main Menu/Diagnostics/Faults.
- If a human interface module is connected to the controller, press the Stop button.

  Note: A stop signal from the HIM will always stop the motor and clear the fault regardless of Logic Mask configuration (Logic Mask, parameter #87, equals ø).
- If a RESET push button is present, the N.O. push button auxiliary contact can be connected to Option Input #2 (terminal 15). Option Input #2 must be programmed for Clear Fault.
- Cycle control power to the SMC-Flex controller.

Important: An overload fault cannot be reset until the Motor Thermal Usage, parameter 12, value is below 75%. See *Protection and Diagnostics* on page 1-9 for further details.

Fault Buffer

The SMC-Flex controller stores in memory the five most recent faults. Display the fault buffer by selecting the View Faults Queue and scrolling through the fault buffer parameters. The information is stored as fault codes and fault descriptions. A fault code cross-reference is provided in Table 7.A.

Fault Codes

Table 7.A provides a complete cross-reference of the available fault codes and corresponding fault descriptions.

Table 7.A
Fault Code Cross-Reference

Fault	Code	Fault	Code
Line Loss A	1	Stall	25
Line Loss B	2	Phase Reversal	26
Line Loss C	3	Coms Loss P2	27
Shorted SCR A	4	Coms Loss P3	28
Shorted SCR B	5	Coms Loss P5	29
Shorted SCR C	6	Network P2	30
Open Gate A	7	Network P3	31
Open Gate B	8	Network P5	32
Open Gate C	9	Ground Fault	33
PTC Pwr Pole	10	Excess Starts/Hour	34
SCR Overtemp ❶	11	Power Loss A	35
Motor PTC	12	Power Loss B	36
Open Bypass A	13	Power Loss C	37
Open Bypass B	14	Hall ID	38
Open Bypass C	15	NVS Error	39
No Load A	16	No Load	40
No Load B	17	Line Loss A	41
No Load C	18	Line Loss B	42
Line Imbalance	19	Line Loss C	43
Overvoltage	20	V24 Loss	45
Undervoltage	21	V Control Loss	46
Overload	22	Input 1	48
Underload	23	Input 2	49
Jam	24	System Faults	128…209

❶ Not applicable in MV applications.

Fault and Alarm Auxiliary Indication

Auxiliary contacts can be programmed for Fault or Alarm, N.O. or N.C. indication. Parameter setup can be found in the Parameter/Motor Protection group when modifying parameters in the Program Mode.

Fault Definitions

Table 7.B – Fault Definitions for the SMC-Flex ❸

Fault	Description
Line Loss (F1, F2, F3)	The SMC-Flex can determine if a line connection has been lost, and will indicate this accordingly.
Shorted SCR	Shorted SCRs will be detected and starting will be prohibited by the SMC-Flex.
Open Gate	Open gate indicates that an abnormal condition that causes faulty firing (e.g., open SCR gate or faulty gate driver) has been sensed during the start sequence. The SMC-Flex controller will attempt to start the motor a total of three times before the controller shuts down.
Power Pole PTC Overtemperature	The power pole temperature in each phase is monitored. If the temperature rises above the predetermined level, the unit will fault to protect the power pole. A reset can be performed once the temperature falls below this level. This fault may also represent loss of gate driver power during gating (MV applications only).
Motor PTC	A motor PTC can be connected to terminals 23 and 24. If the PTC parameter is enabled and the PTC trips, the SMC-Flex will trip and indicate a Motor PTC fault.
Open Bypass	Power Pole bypass contacts are monitored for proper operation. In the event of a contact failure, the SMC-Flex will indicate an Open Bypass fault.
No Load	The SMC-Flex can determine if a load connection has been lost, and No Load fault will be indicated.
Line Unbalance ❶	Voltage unbalance is detected by monitoring the three phase supply voltages. The formula used to calculate the percentage voltage unbalance is as follows: $V_u = 100\ (V_d / V_a)$ V_u: Percent voltage unbalance V_d: Maximum voltage deviation from the average voltage V_a: Average voltage The controller will shut down when the calculated voltage unbalance reaches the user-programmed trip percentages.
Overvoltage and Undervoltage Protection ❶	Overvoltage and undervoltage protection are user-defined as a percentage of the programmed line voltage. The SMC-Flex controller continuously monitors the three supply phases. The calculated average is then compared to the programmed trip level.
Underload ❷	Underload protection is available for undercurrent monitoring. The controller will shut down when the motor current drops below the trip level. This trip level, a percentage of the motor's full load current rating, can be programmed.
Overload Protection	Overload protection is enabled in the Motor Protection group by programming the: • Overload class • Overload reset • Motor FLC • Service factor Refer to Chapter 5 for more information on Motor Protection.
Phase Reversal	Phase reversal is indicated when the incoming power to the SMC-Flex controller is in any sequence other than ABC. This pre-start protective feature can be disabled.
Coms Loss	The SMC-Flex controller disables control through the serial communication port as the factory default. To enable control, the Logic Mask found in the Communication programming group must be set to "4." With Series B human interface modules, this can also be accomplished by enabling control logic through the Control Status programming group. If a Bulletin 20-HIM Human interface module or Bulletin 1203 communication module is disconnected from the SMC-Flex controller when control is enabled, a Comm Fault will occur.
Network	Network faults are faults generated on the network external to the SMC-Flex, and are annunciated on the LCD display.
Ground Fault	Ground faults are based on feedback from the user supplied 825 CT detecting ground fault currents. Ground fault parameters of level and time delay must be programmed for proper operation.
Excess Starts/Hour	Excess starts/hour is displayed when the number of starts in a one hour period exceeds the value programmed.
Power Loss	Power loss indicates that an input power phase is not present. The controller's LCD display will identify the missing phase. If all three phases are absent when a start command is issued, the LCD will display "Starting" without motor rotation.
Line Loss (F41, F42, F43)	During expected SCR gate periods, the power pole voltage and currents are monitored. If the SCR conduction is discontinued, a fault is indicated.

❶ Phase loss, overvoltage and undervoltage protection are disabled during braking operation.
❷ Jam detection and underload protection are disabled during slow speed and braking operation.
❸ Additional details regarding fault definitions can be found in Chapter 1 – Product Overview.

Communications

Overview

The SMC-Flex provides advanced communications capabilities that allow it to be started and stopped from multiple sources as well as provide diagnostic information through the use of communication interfaces. The SMC-Flex uses the DPI method of communication, therefore all standard DPI communication interfaces used by other devices (i.e., PowerFlex™ Drives) can be used in the SMC-Flex. ScanPort devices are not supported by the SMC-Flex.

Standard DPI communications cards are available for various protocols including DeviceNet, ControlNet, Remote I/O, ModBus™, and Profibus® DP. Other modules may be available in the future. For specific programming examples, configuration, or programming information, refer to the user manual for the communication interface being used. A list of available interfaces is located below.

Table 8.A – Communication Interfaces

Protocol Type	Cat. No.	User Manual
DeviceNet	20-COMM-D	20COMM-UM002❶-EN-P
ControlNet	20-COMM-C	20COMM-UM003❶-EN-P
Remote I/O	20-COMM-R	20COMM-UM004❶-EN-P
Profibus®	20-COMM-P	20COMM-UM006❶-EN-P
RS-485	20-COMM-S	20COMM-UM005❶-EN-P
InterBus	20-COMM-I	20COMM-UM007❶-EN-P
EtherNet/IP	20-COMM-E	20COMM-UM010❶-EN-P
RS485 HVAC	20-COMM-H	20COMM-UM09❶-EN-P
LonWorks	20-COMM-L	20COMM-UM08❶-EN-P
ControlNet (Fiber)	20-COMM-Q	20COMM-UM03❶-EN-P

❶ Denotes revision level of user manual. Example: Publication 20COMM-UM002C-EN-P is at revision C.

Communication Ports

The SMC supports three DPI ports for communication. Ports 2 and 3 are supported through the serial connection on the side of the device and are typically used to interface with a Human Interface Module (HIM). Port 2 is the default connection with port 3 available by installing a splitter on port 2. Port 5 is supported by connecting one of the modules listed above to the internal DPI comm card connection.

Human Interface Module

The SMC-FLEX controller can be programmed with the built-in keypad and LCD display or with the optional Bulletin 20-HIM LCD human interface modules. Parameters are organized in a three-level menu structure and divided into programming groups.

Note: Node addressing of the DPI communication card can be programmed via software or a hand-held DPI HIM. The onboard HIM cannot be used to address the communication card.

Keypad Description

The functions of each programming key are described below.

Table 8.B – Keypad Descriptions

Esc	Escape	Exit a menu, cancel a change to a parameter value, or acknowledge a fault/alarm.
Sel	Select	Select a digit, select a bit, or enter edit mode in a parameter screen.
▲ ▼	Up/Down Arrows	Scroll through options increase/decrease a value, or toggle a bit.
↵	Enter	Enter a menu, enter edit mode in a parameter screen, or save a change to a parameter value.

Note: If a human interface module is disconnected from the SMC-Flex controller while the Logic Mask is set to 1, a “Coms Loss” will occur.

Note: For ease of programming values, after using the Enter key to edit, use the Sel key to jump to the digit that needs to be modified, then use the arrow keys to scroll through the digits.

The Bulletin 20-HIM LCD interface modules may be used to program and control the SMC-Flex controller. The human interface modules have two sections: a display panel and a control panel. The display panel duplicates the 3-line, 16-character backlit LCD display and programming keypad found on front of the SMC-Flex controller. Refer to Chapter 4 for a description of the programming keys; refer to Appendix E for a listing of human interface module catalog numbers that are compatible with the controller.

Note: Bulletin 20-HIM Rev3.002 or later must be utilized with the SMC-Flex.

Note: Extension cables are available up to a maximum of 10 m in total length.

Note: A maximum of two HIM modules can be installed.

The control panel provides the operator inteface to the controller.

Start

I

The green start button, when pressed, will begin motor operation. (Proper setup of the HIM port is required.

Stop

O

The red stop button, when pressed, will halt motor operation and/or reset a fault.

Jog

Jog

The jog button is active only when a control option is present. Pressing the jog button will initiate the option maneuver (for example: Pump Stop).

ATTENTION

The Bulletin 20-HIM interface module's stop push button is not intended to be used as an emergency stop. Refer to the applicable standards for emergency stop requirements.

ATTENTION

The external HIM has a similar programming operation to the built-in programmer, but note that differences do exist.

All other controls available with the various human interface modules are non-functional with the SMC-Flex controller.

Connecting the Human Interface Module to the Controller

Figure 8.1 shows the connection of the SMC-Flex controller to a human interface module. Table 8.C provides a description of each port.

Note: The SMC-Flex only supports the use of DPI communication modules and DPI HIM Modules. Scanport devices are not supported by the SMC-Flex.

See Figure 1.21 or 1.24 for the control wiring diagram that enables start-stop control from a human interface module.

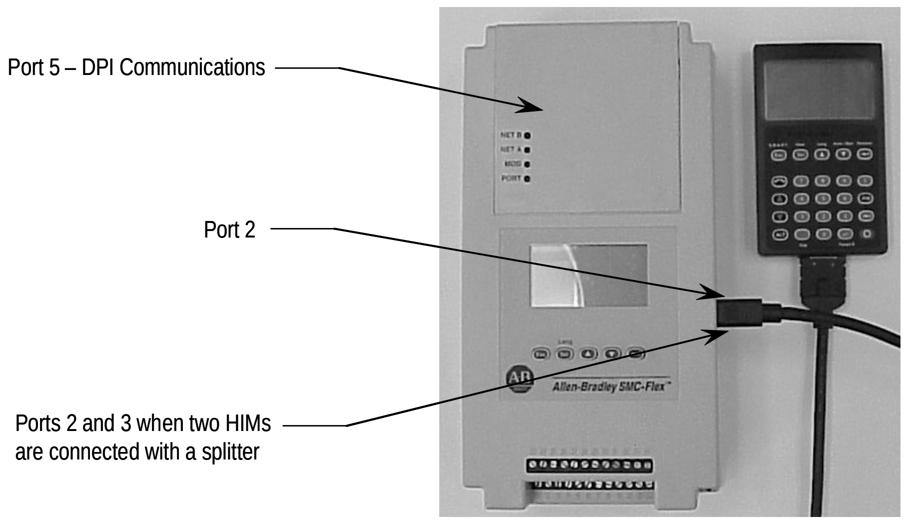


Figure 8.1 – SMC-Flex Controller with Human Interface Module

Table 8.C – Description of Ports

Port #	Description
1	Unused – Not available for use
2	First 20-HIM connected to SMC-Flex
3	Second 20-HIM connected to SMC-Flex
5	DPI Communication Board port

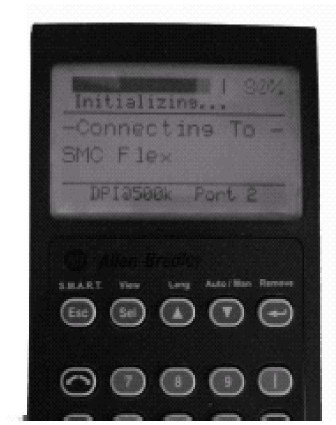
HIM Control Enable

To enable motor control from a connected human interface module, follow the procedure below with the connected human interface module's programming keys.

The Bulletin 20-HIM-LCD human interface modules with control panels can start and stop the SMC-FLEX controller. However, the factory default settings disable control commands other than Stop through the serial communication port.

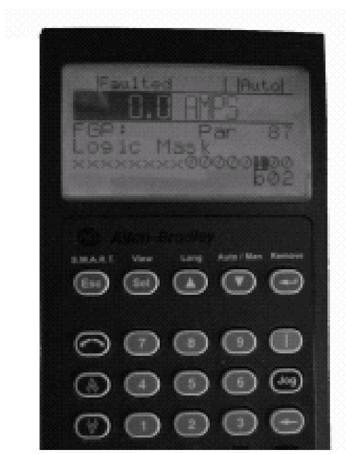
To enable motor control from a connected human interface module or communication module, you must take the following programming steps:

1. Disconnect the HIM and allow to power down.
2. Reconnect the HIM. On Initializing screen, the bottom right corner of LCD shows Port X. Note this port number.



3. Go to Logic Mask, found as follows:

   Main Menu: Parameter/Communications/Comm Mask/Logic Mask



4. Set b0X equal to 1 (where X is the port number noted in step 2).
5. Go to Parameter Management and save as User Store.

Important: The Logic Mask must be set to 0 prior to disconnecting a human interface module from the SMC-FLEX controller. If not, the unit will fault on a “Coms Loss”.

If enabling control from the built-in SMC-Flex programmer, the Logic Mask must be set as follows:

Table 8.D – Logic Mask Requirements

Mask Code	Description
0	No external DPI devices are enabled
4	Only one HIM on port 2 is enabled
12	Two HIMs are enabled on ports 2 and 3
32	Only the DPI communication card on port 5 is enabled
36	One HIM on port 2 and the DPI communication card on port 5 are enabled
44	Two HIMs on ports 2 and 3 and the DPI communication card on port 5 are enabled

Control Enable

The Logic Mask parameter (Parameter 87) allows the user to configure whether a communication device (HIM or network connection) can perform control commands such as starting. Each communication port can be enabled or disabled as required. When a given device is enabled through the logic mask that device is allowed to execute control commands. In addition, disconnecting any device with the logic mask enabled will result in a communication fault unless the communication fault is disabled. When a given device is disabled through the logic mask that device cannot execute control commands, but can still be used for monitoring. A device that is disabled through the logic mask can be disconnected without causing a fault.

IMPORTANT Stop commands override all start commands and can be initiated from the hardwired inputs or any port regardless of the logic mask.

Loss of Communication and Network Faults

The loss of communication fault will follow the functionality as defined in the DPI specification. There will be separate faults for each device. Since three DPI ports are supported there will be three faults that can be generated.

DPI provides a separate network fault for each port. This fault can be generated directly by the peripheral and is separate from the Communications Loss fault (which is actually generated by the SMC-Flex itself).

SMC-Flex Specific Information

The SMC is can be used with all LCD applicable DPI interface. Regardless of the type of interface being used, the information below can be used to configure the rest of the system.

Default Input/Output Configuration

The default configuration for I/O is 4 bytes in and 4 bytes out (TX = 4 bytes, RX = 4 bytes) and is arranged according to the following table.

Table 8.E

	Produced Data (Status)	Consumed Data (Control)
Word 0	Logic Status	Logic Command
Word 1	Feedback ❶	Reference ❷

❶ The feedback word is always Current in Phase A.

❷ The reference word is not used with the SMC-Flex, however the space must be reserved.

Variable Input/Output Configuration

The SMC-Flex supports 16-bit DataLinks. Therefore, the device can be configured to return additional information. The I/O message size depends on how many DataLinks are enabled. The following table summarizes the I/O data sizes.

Table 8.F

Rx Size	Tx Size	Logic Status/ Command (16-bit)	Reference/ Feedback (16-bit)	Data Links			
				A	B	C	D
4	4	X	X				
8	8	X	X	X			
12	12	X	X	X	X		
16	16	X	X	X	X	X	
20	20	X	X	X	X	X	X

To configure DataLinks, refer to ***Configuring Data Links*** on page 8-10.

SMC-Flex Bit Identification

Table 8.G – Logic Status Word

Bit #																Status	Description
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0		
															X	Enabled	1 – Control Power Applied 0 – No Control Power
														X		Running	1 – Power Applied to Motor 0 – Power not Applied to Motor
													X			Phasing	1 – ABC Phasing 0 – CBA Phasing
												X				Phasing Active	1 – 3-phase is valid 0 – No valid 3-phase is detected
											X					Starting (Accel)	1 – Performing a Start Maneuver 0 – Not performing a Start Maneuver
										X						Stopping (Decel)	1 – Performing a Stop Maneuver 0 – Not performing a Stop Maneuver
									X							Alarm	1 – Alarm Present 0 – No Alarm Present
								X								Fault	1 – Fault Condition Exists 0 – No Fault Condition
							X									At Speed	1 – Full Voltage Applied 0 – Not Full Voltage Applied
						X										Start/ Isolation	1 – Start/Isolation Contactor Enabled 0 – Start/Isolation Contactor Disabled
					X											Bypass	1 – Bypass Contactor Enabled 0 – Bypass Contactor Disabled
				X												Ready	1 – Ready 0 – Not Ready
			X													Option 1 Input	1 – Input Active 0 – Input Inactive
		X														Option 2 Input	1 – Input Active 0 – Input Inactive
—																—	Bits 14 and 15 – Not Used

Table 8.H – Logic Command Word (Control)

Bit #																Status	Description
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0		
															X	Stop	1 – Stop/Inhibit 0 – No Action
														X		Start	1 – Start 0 – No Action
													X			Option #1 Input	1 – Stop Maneuver/Inhibit 0 – No Action
												X				Clear Faults	1 – Clear Faults 0 – No Action
											X					Option #2 Input	1 – Perform Option 2 function 0 – No Action
—																—	Bits 5 to 10 – Not Used
				X												Aux Enable	1 – Use Aux 1 to Aux 4 0 – Ignore Aux 1 to Aux 4
			X													Aux 1	1 – Aux 1 Active 0 – Aux 1 Inactive
		X														Aux 2	1 – Aux 2 Active 0 – Aux 2 Inactive
	X															Aux 3	1 – Aux 3 Active 0 – Aux 3 Inactive
X																Aux 4	1 – Aux 4 Active 0 – Aux 4 Inactive

Reference/Feedback

The SMC-Flex does not offer the analog **Reference** feature. The analog **Feedback** feature is supported and will provide Parameter 1, Current in Phase A, automatically as the feedback word.

Parameter Information

A complete listing of the SMC-Flex parameters is located in Appendix B.

Scale Factors for PLC Communication

The parameter values stored and produced by the SMC-Flex through communication are unscaled numbers. When reading or writing values from a PLC image table, it is important to apply the proper scaling factor, which is based on the number of decimal places.

Read Example

Parameter 11; Power Factor — The stored value is 85. Since this value has two decimal places, the value should be divided by 100. The correctly read value is 0.85.

Write Example

Parameter 46; Motor FLC — The value which is to be written to the SMC is 75 A. Since this value has one decimal place, the value should be multiplied by 10. The correctly written value is 750.

Display Text Unit Equivalents

Some parameters have text descriptions when viewed from a HIM or through a communication software program such as RSNetworx™. When receiving or sending information from a PLC each text description has a numerical equivalent. Table 8.I has an example of Parameter 44, Overload Class, and the appropriate relationship between the text descriptor and the equivalent value. This relationship is identical for other similar parameters located in Appendix B.

Table 8.I

Text Descriptor	Numerical Equivalent
Disabled	0
Class 10	1
Class 15	2
Class 20	3
Class 30	4

Configuring DataLinks

DataLinks are supported in the SMC-Flex. A DataLink is a mechanism used by most drives to transfer data to and from the controller without using an Explicit Message. The SMC-Flex supports 16-bit DataLinks, therefore the device can be configured to return up to four additional pieces of information without the need for an explicit message.

Rules for Using DataLinks

- Each set of DataLink parameters in an SMC-Flex can be used by only one adapter. If more than one adapter is connected, multiple adapters must not try to use the same DataLink.
- Parameter settings in the SMC determine the data passed through the DataLink mechanism.
- When you use a DataLink to change a value, the value is not written to the Non-Volatile Storage (NVS). The value is stored in volatile memory and lost when the drive loses power.

Parameters 88 to 103 are used to configure the DataLinks. For additional information regarding DataLinks, refer to the user manual for the communication interface being used.

Note: Node addressing of the DPI communication card can be programmed via software or a hand-held DPI HIM. The on-board HIM cannot be used to address the communication card.

Updating Firmware

The latest version of firmware and instructions for the SMC-Flex can be obtained from www.ab.com.

Note: The MV SMC-Flex must use firmware release 3.006 or later. This User Manual pertains to units with firmware release 4.xxx (or later).

Troubleshooting

General Notes and Warnings

For safety of maintenance personnel as well as others who might be exposed to electrical hazards associated with maintenance activities, follow the local safety related work practices (for example, the NFPA 70E, Part II in the United States). Maintenance personnel must be trained in the safety practices, procedures and requirements that pertain to their respective job assignments.

ATTENTION Hazardous voltage is present in the motor circuit even when the SMC-Flex controller is off. To avoid shock hazard, disconnect main power before working on the controller, motor, or control devices such as Start-Stop push buttons. Procedures that require parts of the equipment to be energized during troubleshooting, testing, etc., must be performed by properly qualified personnel, using appropriate local safety work practices and precautionary measures.

ATTENTION Disconnect the controller from the motor before measuring insulation resistance (IR) of the motor windings. Voltages used for insulation resistance testing can cause SCR failure. Do not make any measurements on the controller with an IR tester (megger).

Note: The time it takes for the motor to come up to speed may be more or less than the time programmed, depending on the frictional load and inertial characteristics of the connected load.

Note: Depending on the application, the Braking options (SMB™ Motor Braking, Accu-Stop and Slow Speed) may cause some vibration or noise during the stopping cycle. This may be minimized by lowering the braking current adjustment. If this is a concern in your application, please consult the factory before implementing these options.

For MV SMC-Flex technical support on start-up or existing installations, contact your Rockwell Automation representative. You can also call 1-519-740-4790 for assistance Monday through Friday from 9:00 a.m. to 5:00 p.m. (Eastern time zone).

Important: In the case of the 1503E, refer to applicable documentation from OEM for troubleshooting or repair. This manual should be utilized in conjunction with the OEM supplied documentation, and is suitable for commissioning, programming, calibration, metering, serial communications, diagnostics, troubleshooting and maintenance of a standard solid-state controller.

The following flowchart is provided to aid in quick troubleshooting.

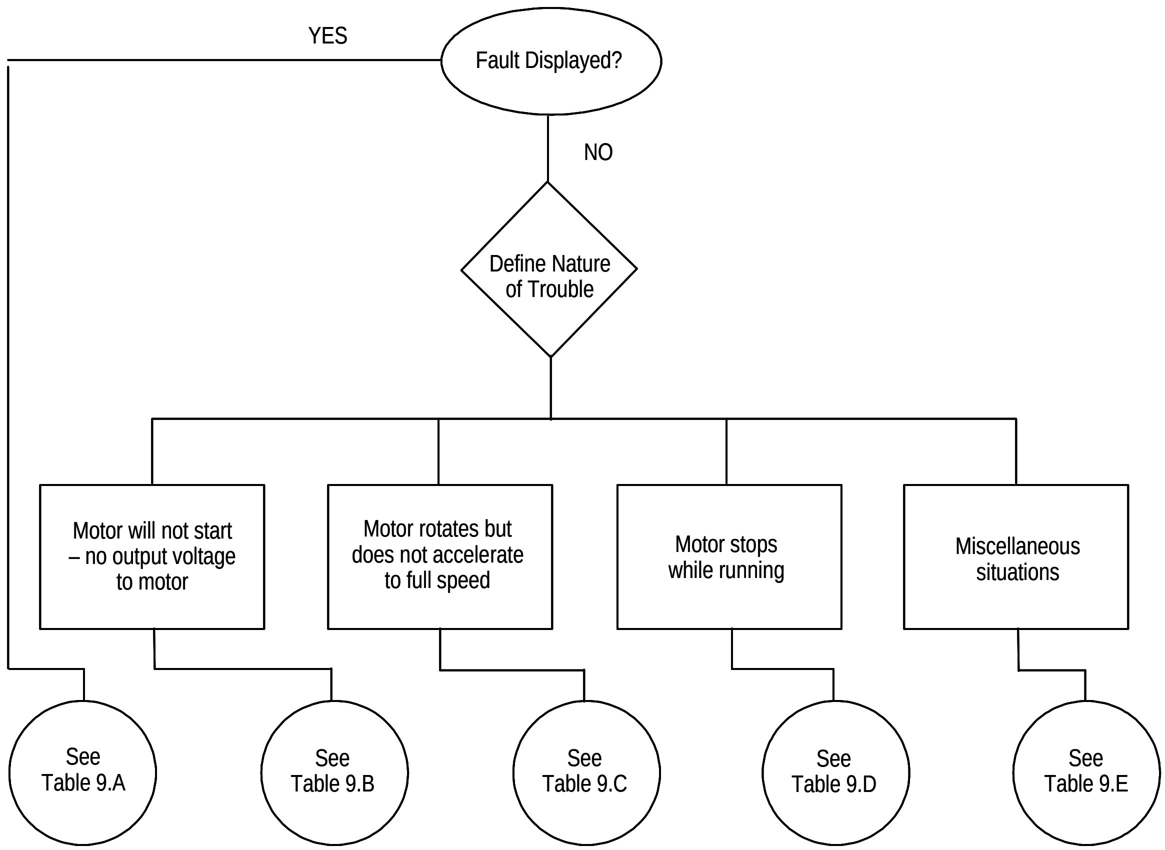


Figure 9.1 – Troubleshooting Flowchart

Table 9.A – Fault Display Explanation

Display	Fault Code	Possible Causes	Possible Solutions
Line Loss (with phase indication)	1, 2, 3	• Missing supply phase • Motor not connected properly • Improper or missing current or voltage feedback	• Check for open line (e.g. blown line fuse) • Check for open load lead • Check current transformer connections and module programming • Check voltage sensing board connections and module programming • Check ribbon cable connections between Interface Board and Control Module • Check voltage feedback circuits • Consult factory
Shorted SCR	4, 5 and 6	• Shorted Power Module	• Check for shorted SCR, replace if necessary (See Power Circuit Troubleshooting)
Open Gate (with phase indication)	7, 8 and 9	• Open gate circuitry • Loose gate lead	• Perform power supply tests (Chapter 3) • Check gate lead connections to the gate driver boards and fiber optics
PTC Power Pole	10	• Controller ventilation blocked • Controller duty cycle exceeded • Fan failure • Ambient temperature limit exceeded • Failed thermistor • Failed control module • Failed gate driver board • Failed fiber optic cable • Failed interface board	• Check for proper ventilation • Check application duty cycle • Replace fan • Wait for controller to cool or provide external cooling • Check connection or replace thermistor • Replace control module • Test or replace gate driver board • Test or replace cable • Test or replace interface board; check ribbon cables
Motor PTC	12	• Motor ventilation blocked • Motor duty cycle exceeded • PTC open	• Check for proper ventilation • Check application duty cycle • Wait for motor to cool or provide external cooling • Check resistance of PTC
Open Bypass	13, 14, 15	• Control voltage is low • Inoperable bypass contactor • IntelliVAC fault	• Check control voltage power supply • Check control circuit operation • Check control plug on contactor • Check status of IntelliVAC, correct the condition, reset the module
No load	16, 17, 18, 40	• Loss of load side power wiring • Loss of feedback	• Check all load side power connections and motor windings • Check voltage sensing module
Line Unbalance	19	• Supply unbalance is greater than the user-programmed value • The delay time is too short for the application • Unbalanced feedback	• Check power system and correct if necessary • Extend the delay time to match the application requirements • Check voltage sensing module
Overvoltage	20	• Supply voltage is greater than user-programmed value	• Check power system and correct if necessary • Correct the user-programmed value
Undervoltage	21	• Supply voltage is less than user-programmed value • The delay time is too short for the application	• Check power system and correct if necessary • Correct the user-programmed value • Extend the delay time to match the application requirements.
Overload	22	• Motor overloaded • Overload parameters are not matched to the motor	• Check motor overload condition • Check programmed values for overload class and motor FLC
Underload	23	• Broken motor shaft • Broken belts, tool bits, etc. • Pump cavitation	• Repair or replace motor • Check machine • Check pump system
Jam	24	• Motor current has exceeded the user programmed jam level	• Correct source of jam • Check programmed time value
Stall	25	• Motor has not reached full speed by the end of the programmed ramp time	• Correct source of stall

Table 9.A – Fault Display Explanation (cont.)

Display	Fault Code	Possible Causes	Possible Solutions
Phase Reversal	26	• Incoming supply voltage is not in the expected ABC sequence	• Check power wiring • Disable protection if not needed
Comm Loss	27, 28, 29	• Communication disconnection at the serial port	• Check for a communication cable disconnection to the SMC-Flex controller
Network	30, 31, 32	• DPI network loss	• Reconnect for each DPI connected device
Ground Fault	33	• Ground fault current level has exceeded programmed values	• Check power system and motor; correct if necessary • Check programmed ground fault levels to match application requirements
Excess Starts/Hr.	34	• Number of starts in a one-hour period has exceeded the value programmed	• Wait an appropriate amount of time to restart • Consult factory if more than 2 starts per hour are required
Power Loss ❶ (with phase indication)	35, 36, 37	• Missing supply phase (as indicated) • Loss of feedback	• Check for open line (i.e., blown line fuse) • Check CT connections, replace Interface board
Hall ID	38	• Faulty interface	• Check ribbon cable connections between interface board and control module • Replace interface board
NVS Error	39	• Data entry error	• Check user data and perform a User Store function • Replace control module
Line Loss	41, 42, 43	• Line Distortion • High impedance connection	• Check supply voltage for capability to start/stop motor • Check for loose connections on line side or motor side power wires
System Faults	128 to 209	• Control module internal fault	• Cycle control power to reset the control module • If fault persists, replace control module

❶ Prestart fault indication

Table 9.B – Motor Will Not Start – No Output Voltage to the Motor

Display	Possible Causes	Possible Solutions
Fault displayed	• See fault description	• See Table 9.A addressing fault conditions
Display is blank	• Control voltage is absent • Failed control module	• Check control wiring and correct if necessary • Replace control module
Stopped 0.0 Amps	• Pilot devices • SMC Enable input is open at terminal 13 • Terminal 16 is open • Start-Stop control has not been enabled for the human interface module • Control voltage • Failed control module	• Check wiring • Check wiring • Check wiring • Follow the instructions on page 2-16 to 2-18 to enable control capability • Check control voltage • Replace control module
Starting	• Two or three power phases are missing	• Check power system • Check voltage sensing module and connections

Table 9.C – Motor Rotates (but does not accelerate to full speed)

Display	Possible Causes	Possible Solutions
Fault displayed ❶	• See fault description	• See Table 9.A addressing fault conditions
Starting	• Mechanical problems • Inadequate Current Limit setting • Failed control module	• Check for binding or external loading and correct • Check motor • Adjust the Current Limit Level to a higher setting • Replace control module

❶ Verify that the Neutral connection on the Interface board matches your power system grounding scheme. If the power system is truly ungrounded, the Neutral connection on the Interface board must not be connected. If the power system is grounded (solid, resistance, zig-zag, etc.), the Neutral connection must be connected to the green terminal block in the control panel. (See Chapter 3 – Commissioning)

Table 9.D – Motor Stops While Running

Display	Possible Causes	Possible Solutions
Fault displayed	• See fault description	• See Table 9.A addressing fault conditions
Display is blank	• Control voltage is absent • Failed control module	• Check control wiring and correct if necessary • Replace control module
Stopped 0.0 Amps	• Pilot devices • Failed control module	• Check control wiring and correct if necessary • Replace control module
Starting	• Two or three power phases are missing • Failed control module	• Check power system • Check voltage sensing module and connections • Replace control module

Table 9.E – Miscellaneous Situations ❶

Display	Possible Causes	Possible Solutions
Motor current and voltage fluctuates with steady load	• Motor • Erratic Load	• Verity type of motor as a standard squirrel cage induction motor • Check load conditions
Erratic operation	• Loose connections	• Shut off all power to controller and check for loose connections
Accelerates too fast	• Starting time • Initial torque • Current limit setting • Kickstart	• Increase starting time • Lower initial torque setting • Decrease current limit setting • Lower kickstart time or turn off
Accelerates too slow	• Starting time • Initial torque • Current limit setting • Kickstart	• Decrease starting time • Increase initial torque setting • Increase current limit setting • Increase kickstart time or turn off
Fan does not operate	• Wiring • Failed fans(s)	• Check wiring and correct if necessary • Replace fan(s)
Motor stops too quickly with Soft Stop option	• Time setting	• Verify the programmed stopping time and correct if necessary
Motor stops too slowly with Soft Stop option	• Stopping time setting • Misapplication	• Verify the programmed stopping time and correct if necessary • The Soft Stop option is intended to extend the stopping time for loads that stop suddenly when power is removed from the motor.
Fluid surges with pumps still occur with the Soft Stop option	• Misapplication	• Soft Stop ramps voltage down over a set period of time. In the case of pumps, the voltage may drop too rapidly to prevent surges. A closed loop system such as Pump Control would be more appropriately suited. • Refer to Publication 150-911
Motor overheats	• Overload • Blocked ventilation • Duty cycle	• Allow motor to cool and reduce load. • Remove blockage and ensure motor is being adequately cooled. • Preset Slow Speed and Accu-Stop options: Extended operation at slow speeds reduces motor cooling efficiency. Consult motor manufacturer for motor limitations. • Smart Motor Braking option: Check duty cycle. Consult motor manufacturer for motor limitations.
Motor short circuit	• Winding fault	• Identify fault and correct • Check for shorted SCR; replace if necessary • Ensure power terminals are secure
Motor coasts when option stop is programmed	• Option not programmed • Current loop power supply not active • Incorrect control logic	• Verify the option parameter settings and correct if necessary • Verify current loop power supply (see Chapter 3, Power Supply Tests) • Verify connections to module terminals 16 and 17 (see Chapter 1, Functional Description)

❶ Various faults may occur if Parameter #15 is set to “Delta”. It must be set to “Line” for all MV applications.

NOTE: For Pump Stop issues, please refer to “Pump Application Considerations” on page 1-21.

Control Module Removal

The control module is not intended for field repair. The entire module must be replaced in the event of failure. The following procedure must be followed before unplugging the control module.

1. Remove all power from the equipment.

SHOCK HAZARD

To avoid shock hazard, ensure the main power has been disconnected before working on the controller, motor or control devices. Verify that all circuits are voltage free using a hot stick or appropriate voltage measuring device. Failure to do so may result in burns, injury or death.

2. Make sure that the wires are properly marked and that the program parameters are recorded.

3. Disconnect all control wires to control module.

4. Loosen the four control module screws.

5. Carefully rotate the module to the left, and unplug the five ribbon cables from the interface board.

ATTENTION

When removing the control module, make sure to hold the module in place as the screws are removed, to avoid strain on the ribbon cables.

To install control module, follow the reverse order for removal.

Note: The MV SMC-Flex must use firmware release 3.006 or later. This User Manual pertains to units with firmware released 4.xxx (or later).

Voltage Feedback Circuit Tests

The most straightforward means of checking the feedback circuits is to perform the "snubber and resistor testing" procedure, found on page 9-26. Another possible test involves measuring the feedback voltages at the interface board (see Figure 3.2). This can only be done with line voltage applied. If the motor does not start, it may be necessary to temporarily modify the control circuit to close the line contactor without applying a start signal to the SMC-Flex module. In this case, the three line voltages (Line A, Line B, Line C) measured with respect to ground should be as follows (check all three phases):

Table 9.F – Voltage Feedback Measurements

System Voltage (V_{LL})	Feedback Voltage	System Voltage (V_{LL})	Feedback Voltage
1000	1.9 – 2.1	4160	1.5 – 1.7
1300	2.4 – 2.6	4800	1.0 – 1.2
1500	2.8 – 3.0	5500	1.1 – 1.3
2400	1.8 – 2.0	6600	1.4 – 1.5
3300	1.2 – 1.4	6900	1.5 – 1.6

If any voltage is well outside this range, there may be a problem either with the system voltage, or with the voltage sensing board. Note that the load side voltages (Load A, Load B, Load C) will be very low, since the SCRs are not turned on, and only a low leakage current flows to the motor.

If the motor will start and run, the line and load voltages should be the same when the bypass contactor is closed.

Voltage-Sensing Board Replacement

1. Ensure there is no power to the equipment.

SHOCK HAZARD

To prevent electrical shock, ensure the main power has been disconnected before working on the sensing board. Verify that all circuits are voltage free using a hot stick or appropriate high voltage-measuring defice. Failure to do so may result in injury or death.

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2. Mark the position of the ribbon cable and wires.
3. Remove the screws and lift the ring lugs from the terminals to remove the wires.
4. Release the locking mechanism located on each side of the ribbon cable connector and pull the ribbon cable straight out to prevent bending the pins.
5. Remove the 4 nuts that secure the assembly to the side panel.
6. Replace with the new assembly securing with all 4 nuts and washers. (See diagram below)
7. Replace ring lugs on terminals. Plug in ribbon cable making sure that it is positioned properly and fitting is secure (locking mechanism is engaged).
8. For personnel and equipment safety, ensure both grounding connections are reconnected to the sensing board.

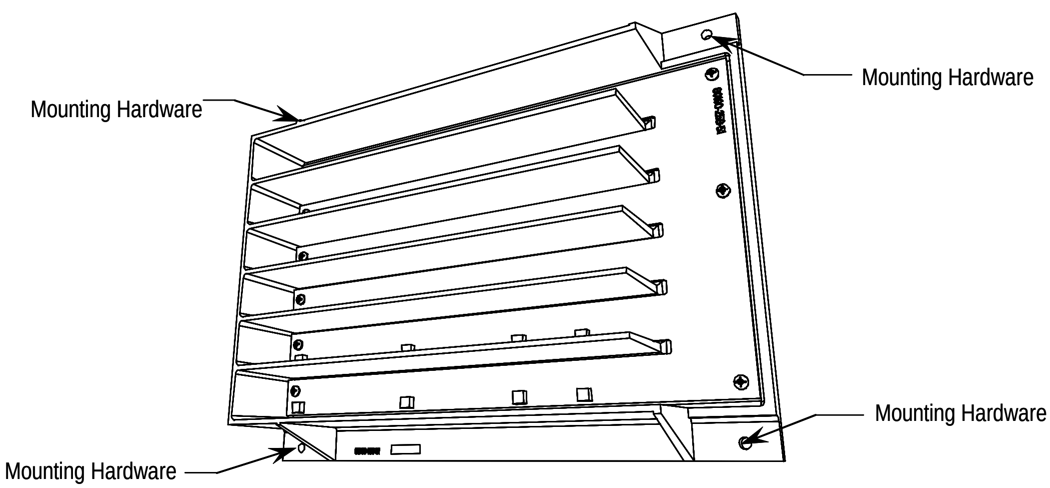


Figure 9.2 – Sensing Board with mounting hardware placement

Current Loop Power Supply

The current loop gate driver (CLGD) boards receive power from two sources:

1. The snubber circuit (while the SCR power modules are active).
2. The current loop power supply, which maintains a pre-charge level of power during periods when the SCR power modules are inactive (this allows SCR gating while the snubber circuit is being charged).

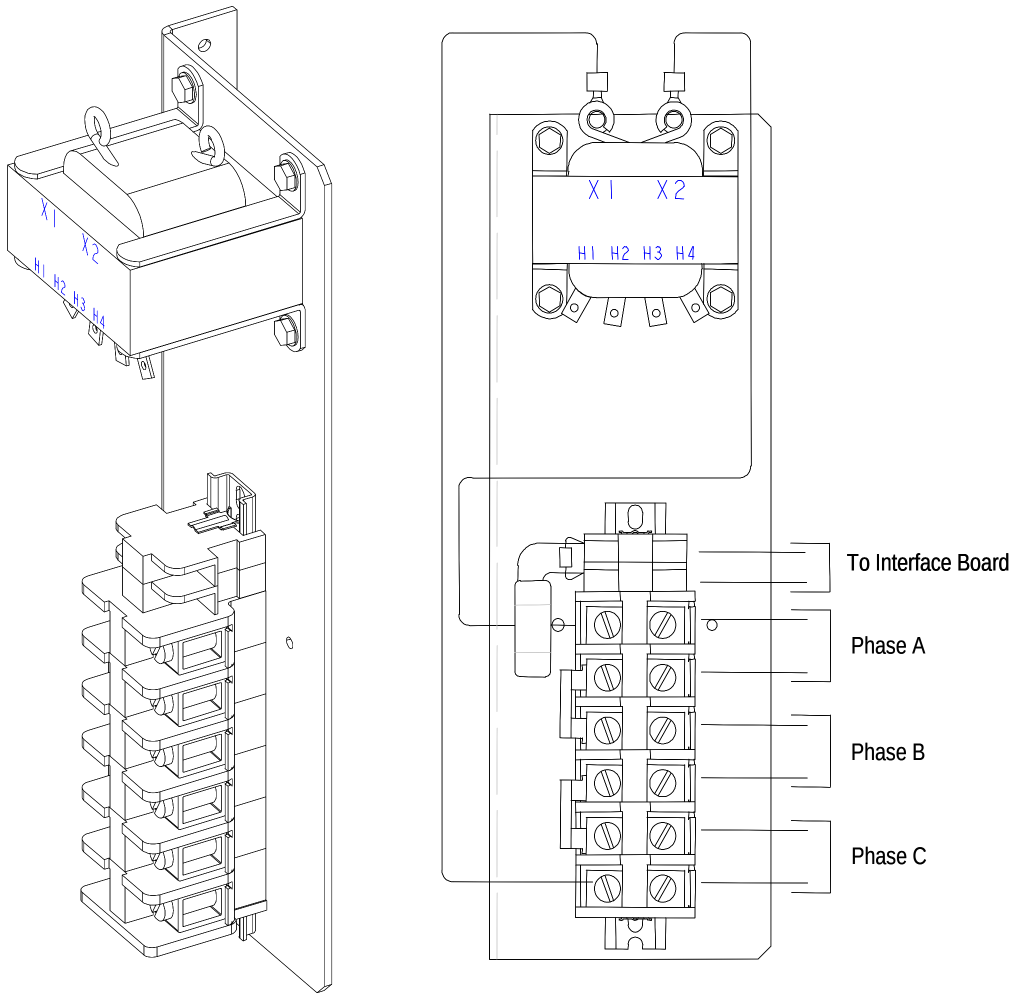


Figure 9.3 – Current Loop Power Supply

The current loop power supply provides a current of 50 AC to each SCR power module phase assembly. If this current is not detected and fed back to the interface boards, stop maneuvers will not function (and an Alarm will be generated).

Circuit Board Replacement

The replacement of printed circuit boards is straightforward, however, there are a number of precautions which must be considered when handling the boards.

ATTENTION Some circuit boards may contain CMOS components which can be destroyed by static charges generated by friction of materials made with synthetic fibres. Use of damaged circuit boards may also damage related components. A grounding wrist strap is recommended for handling sensitive circuit boards.

1. Remove all power from the equipment.

ATTENTION To avoid shock hazard, ensure the main power has been disconnected before working on the controller, motor or control devices. Verify that all circuits are voltage free using a hot stick or appropriate voltage measuring device. Failure to do so may result in burns, injury or death.

2. Carefully detach all wires, cables and connectors, noting their location and orientation. For the interface board, remove the control module (see page 9-6).

ATTENTION The fibre-optic cables can be damaged if struck or bent sharply. They have a locking feature which requires pinching the tab on the connector and gently pulling straight out. The component on the printed circuit board should be held to prevent damage.

3. For boards mounted with hardware, remove the hardware, taking care not to drop anything onto other circuits. For boards with nylon stand-off posts, squeeze the section above the board and carefully pull the board up and off the post.

4. Lift out the circuit board, and check that the replacement board is the correct part number and revision before installation (refer to Appendix D). Install the new board by replacing the hardware, or pressing down onto nylon stand offs. Connect all wires, cables and connectors. Ensure that all switch and/or jumper settings on the new board are identical to those on the old board, and correct for the application.

Power Circuit Troubleshooting

Thyristor (SCR) Testing

If a power semiconductor is suspected of malfunctioning, it may be checked as follows:

1. Remove all power from the equipment.

SHOCK HAZARD

To avoid shock hazard, ensure the main power has been disconnected before working on the controller, motor or control devices. Verify that all circuits are voltage free using a hot stick or appropriate voltage measuring device. Failure to do so may result in burns, injury or death.

2. Measure DC resistance per the following chart:

Table 9.H – SCR Resistance Measurements

Location of Probes	1000 V	1300 V	1500 V	2300 V	3300 V	4160 V	5500 V	6900 V
Cathode to Cathode (KOhms) ❶	–	–	–	–	22-30	23-31	21-29	24-32
Cathode to Cathode (KOhms) ❷	17-23	19-25	20-27	21-29	40-53	43-57	60-80 ❸	64-84 ❸
Cathode to Gate (Ohms)	10-40	10-40	10-40	10-40	10-40	10-40	10-40	10-40

❶ Measured between terminals “Cathode” on SPGD Boards, upper two or bottom two within a phase.
❷ Measured between terminals “Cathode” on SPGD Boards, top to bottom within a phase.
❸ Measured between line and load terminals within a phase.

Note: The actual resistance value depends on the ohmmeter used, the particular brand/rating of SCR and external circuit influences. It is impossible to accurately measure the condition of the SCR when it is unclamped!

3. If a short circuit is suspected, the SCR must be isolated from all surrounding circuitry (i.e. unplug gate and cathode leads, and remove snubber and resistor circuit leads from the driver boards). Measure resistance to confirm state of the SCRs. If the SCRs are not shorted, proceed to snubber and resistor circuit testing, following this procedure.

4. If a faulty device is found, the entire heatsink assembly must be removed.

ATTENTION

For heatsink assemblies containing four or more SCRs, the entire matched set shall be replaced. Devices connected in series must have performance specifications matched for proper operation. Failure to use matched sets may result in damage to the devices.

5. Complete heatsink assemblies with matched SCRs are available as a renewal part (see Appendix D). In most cases, the assembly can be dismantled to replace the SCRs.

SCR Replacement Procedure

Note: This procedure applies to 180A and 360A units < 5000V only.

Important: Refer to OEM documentation for SCR stack location in 1503E.

A. Remove SCR Stack from Unit

For all types of SMCs, the stack requiring new SCRs must first be removed from the unit as follows:

1. Remove all power from the equipment.

SHOCK HAZARD

To avoid shock hazard, ensure main power has been disconnected before working on the controller, motor or control devices. Verify that all circuits are voltage free using a hot stick or appropriate voltage measuring device. Failure to do so may result in burns, injury or death.

2. Service to phase A module may require removing the medium voltage door and swinging out the low voltage panel (for 36-inch wide, two-high cabinet only); see the low voltage panel, Fig. 9.4.

3. Remove current loop cable (see page 9-9).

4. Unplug all fibre-optic cables from the gate-driver board. Unplug gate lead connectors and thermistor connectors. Remove leads from the left side of the circuit board.

ATTENTION

The grey fibre-optic cables can be damaged if struck or bent sharply. They have a locking feature which requires pinching the tab on the connector and gently pulling straight out. The component on the printed circuit board should be held to prevent damage.

5. Remove gate-driver board by compressing the locking tabs of the nylon circuit board supports and carefully pulling the board off the supports.

6. Disconnect the power cables from the terminals on the left side of the heatsink assembly. Use care not to damage components. The sharing resistors are fragile.

Power Circuit Troubleshooting (cont.)

SCR Replacement Procedure (cont.)

7. Remove two (2) nuts at bottom front of heatsink assembly so the module can be removed using the pull handle. (Phase C requires angling the module to clear the front cabinet flange). Position fibre-optic cables and wiring so they will not be damaged as the module is removed from the cabinet.

8. Pull module out slowly, and slide onto a platform lift, or lift the module out of the cabinet.

ATTENTION

The heatsink assembly is heavy (approx. 25 kg [55 lb] or greater). To avoid injury, always use two people to remove and handle the assembly. Place the heatsink on a cart to aid in its transport.

---

9. Place the module on a flat surface (see Fig. 9.7, 9.10 and 9.14). When tilting the module, ensure that wires are not damaged.

B. Replace SCRs

Note: For 600 A units, it is mandatory that the entire stack be replaced. The high clamping force requires the factory to tighten the clamp hardware. See Appendix D, Spare Parts section, for part numbers. Proceed to step C.

Note:
- Refer to Figures 9.5 to 9.16.
- SCR positions are numbered in succession from the top down.
- The SCR cathode is at the end with the wide flange.

ATTENTION

The SCRs must be oriented correctly with the cathode end either up or down, depending on the specific assembly. Note the orientation before removing the SCRs, and refer to the detail in the appropriate figure in this chapter.

---

1. Remove the shorting bar. Measure the resistance between adjacent heatsinks to determine which SCR(s) is (are) shorted. Assemblies with four or six SCRs must use matched sets. See Figures 9.8 and 9.14 for the position of the matched sets. If an SCR from each set is shorted, all of the SCRs in the module must be replaced. A properly functionning SCR will measure in excess of 100 kilohms from anode to cathode, and 10-40 ohms from gate to cathode.

SCR Replacement Procedure (cont.)

Important: DO NOT loosen any of the nuts on the fiber rods on either side of the clamp bars. They must remain as they are to maintain squareness. See Figures 9.6, 9.9 and 9.15.

2. Loosen the clamp by rotating the centre nut below the indicator washer at the top end of the clamp. Refer to Figures 9.6, 9.9 and 9.15.

As the centre nut is rotated, the entire spring assembly is retracted from the top heatsink. Continue to retract until there is a gap of approximately 6 mm (0.25 in).

3. The heatsinks may now be spread apart to allow removal of the SCRs.

4. Apply a thin film of Electrical Joint Compound (supplied) to both faces of the new SCRs.

5. Place the new SCRs in position starting from the top and pushing the heat sinks together as you proceed down the stack. Make sure the SCRs are positioned and oriented properly. Refer to Figures 9.7, 9.10, and 9.16.

6. Ensure that the SCRs are properly seated on the locating pins in the heatsinks and rotate each SCR so that the leads are oriented toward the front right side of the assembly.

7. Advance the centre nut until the spring assembly engages the top heatsink. Make sure the clamp is properly seated on the locating pins in the top and bottom heatsinks before beginning to tighten.

8. Tighten the centre nut until the indicator washer becomes loose with some friction. The clamp is now at the proper force and must not be clamped any tighter. If the indicator washer becomes too loose (no friction), back the centre nut off slowly until the washer is loose with some friction.

9. Replace the shorting bar. Torque hardware to 30 N-m (20 ft-lb). For 3/8-in. hardware in the 'T' slots of aluminum heatsinks, the recommended torque is 22 N-m (16 ft-lb). Do not overtorque these connnections as the slots will be damaged and the connection will be compromised.

Power Circuit Troubleshooting (cont.)

SCR Replacement Procedure (cont.)

C. Install Refurbished Stack

1. Inspect all connections on the module. Inspect wire insulation and components for damage.

2. Install the module in the cabinet. Watch for power cables and fibre-optic cables as module is slid into place. Tighten locking nuts at the bottom of the module.

3. Connect power cables and tighten hardware to 30 N-m (20 ft-lb).

4. Install gate-driver board, ensuring that the locking tabs on the nylon circuit board supports are all engaged. Plug in thermistor and gate connectors and reconnect wires to the left side of the board. Plug in the fibre-optic cables.

5. Replace current loop cable (see page 9-9). Tighten the terminals at the current loop power supply to 5.6 N-m (50 in-lb).

6. Make sure all connections are secure. Perform resistance checks according to instructions on "Thyristor (SCR) Testing" (page 9-12), and test gate-drive circuits by performing power supply tests in Chapter 3 (page 3-6).

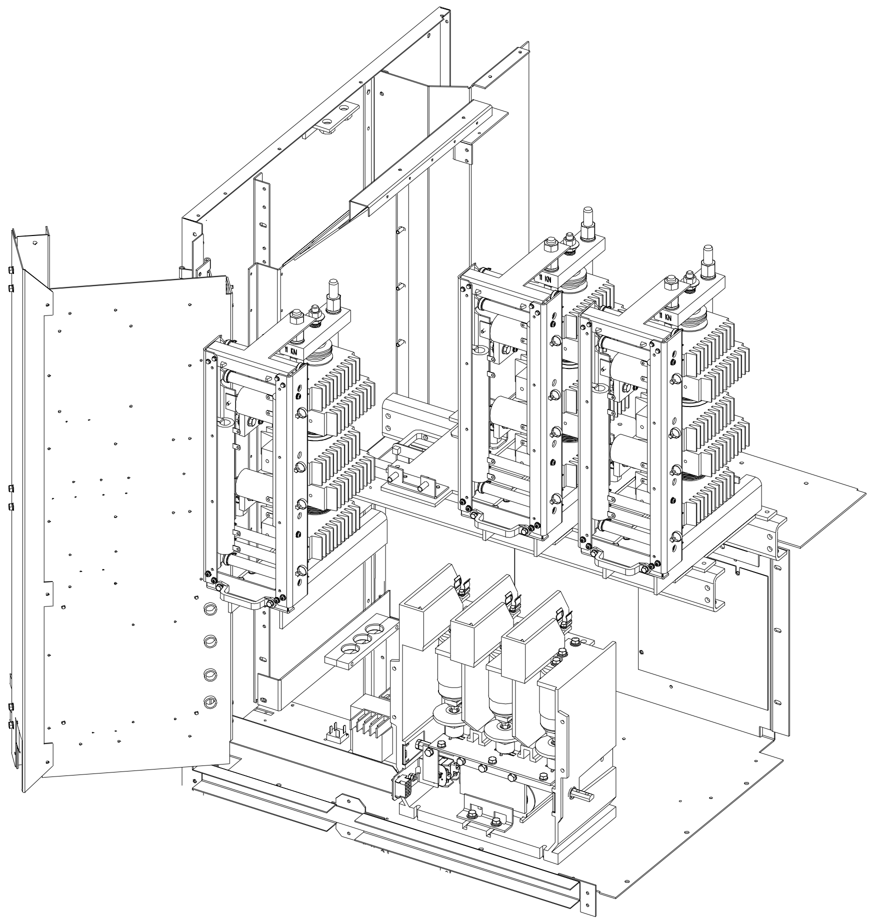


Figure 9.4 – Upper Low Voltage Panel and Power Cell Detail (1562E) • 2400 to 4160 V, 180/360 A

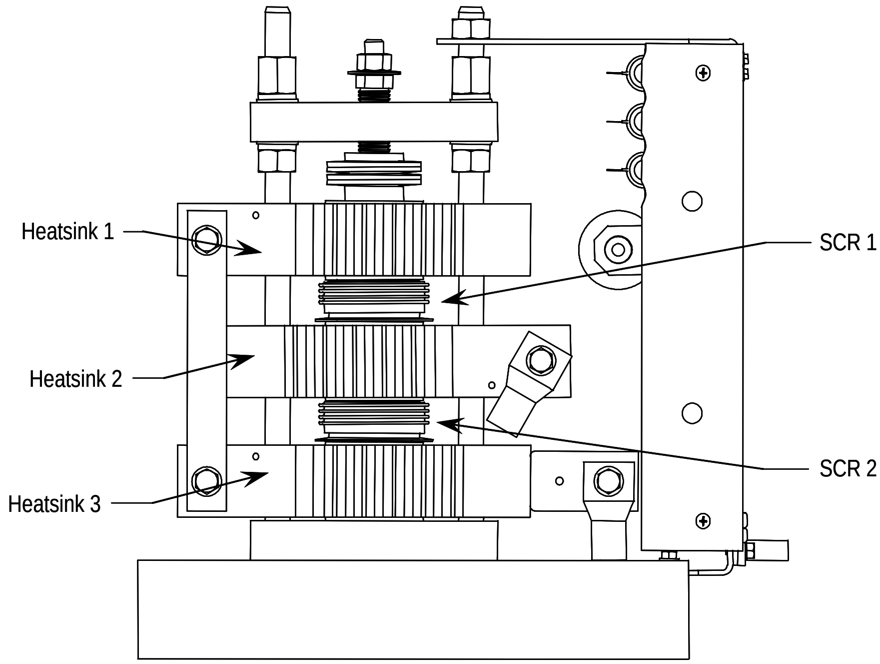
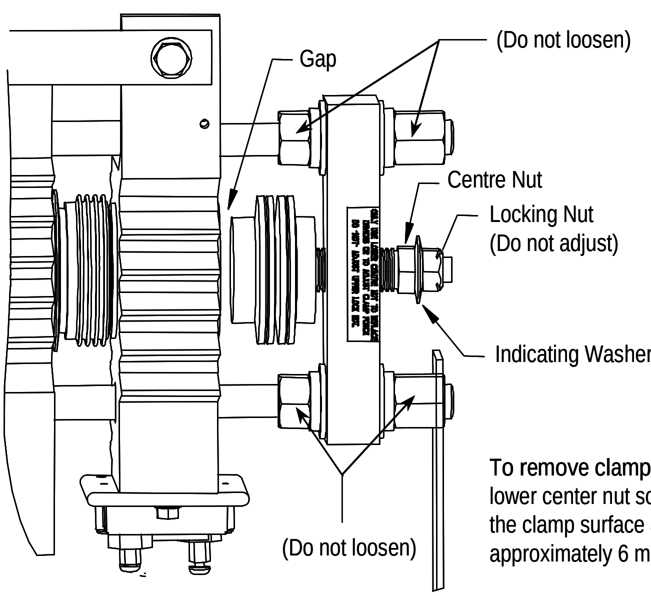


Figure 9.5 – Power Module Assembly (one phase) • 1000/1300/1500/2400 V, 180/360 A



To remove clamp pressure, loosen lower center nut so that the gap between the clamp surface and the heatsink is approximately 6 mm (0.25 in.).

Figure 9.6 – Heatsink Clamp

To Remove SCR:
- Remove shorting bar hardware
- Pry opposing Heatsinks apart
- Extract SCR

To Insert New SCR:
- Apply thin film of electrical joint compound to surfaces of SCR
- Install SCR so that it is seated in locating pin of heatsink (note orientation of SCR).
- Pry heatsinks to close gap, ensuring that SCR is seated properly in both its locating pins.
- Rotate SCR so that all leads have same direction.

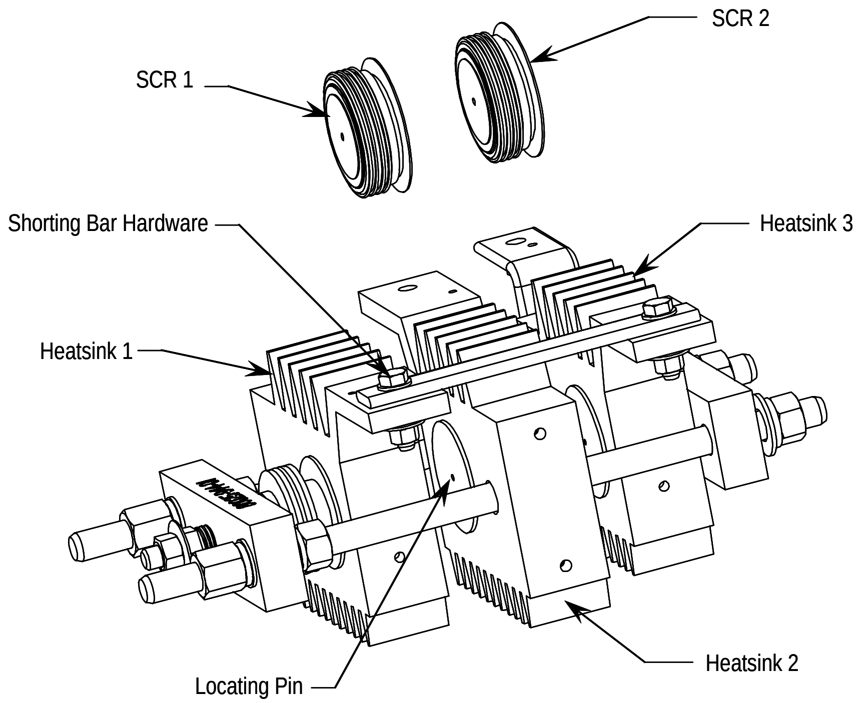


Figure 9.7 – Removal of SCR (1000 to 2400 V, 180/360 A)

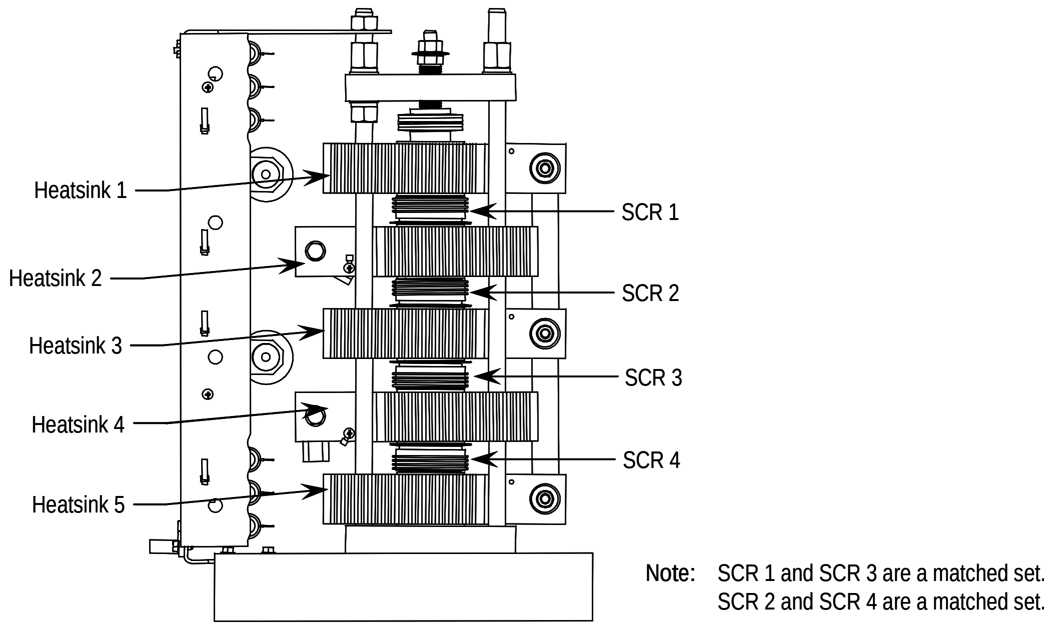


Figure 9.8 – Power Module Assembly (one phase) • 3300/4160 V, 180/360 A

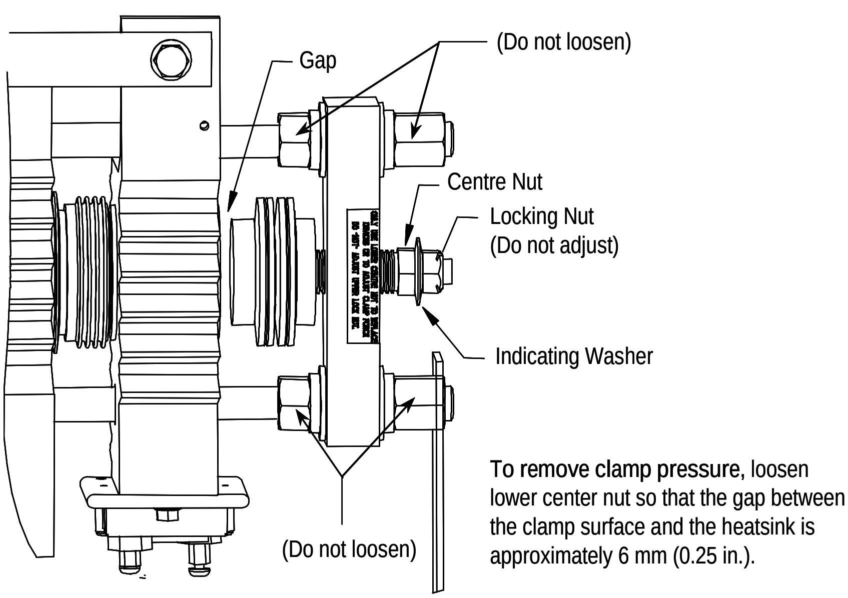


Figure 9.9 – Heatsink Clamp

To Remove SCR4:
- Remove shorting bar hardware
- Pry Heatsinks 4 and 5 apart
- Extract SCR

To Insert New SCR:
- Apply thin film of electrical joint compound to surfaces of SCR
- Install SCR so that it is seated in locating pin of heatsink (note orientation of SCR).
- Pry heatsinks to close gap, ensuring that SCR is seated properly in both its locating pins.
- Rotate SCR so that all leads have same direction.

Proceed to replace SCR's matched pair (SCR2).

Note: You must replace both SCRs of a matched set.

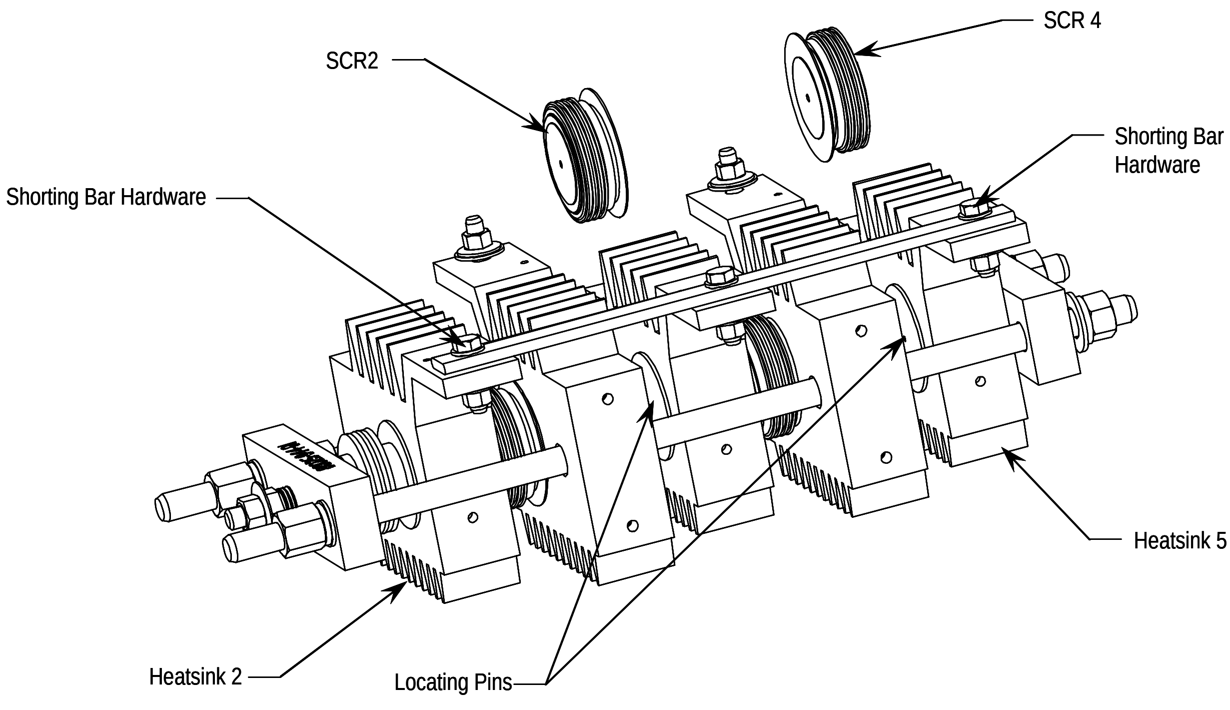


Figure 9.10 – Removal of SCR2 and SCR4 (3300 to 4160 V, 180/360 A)

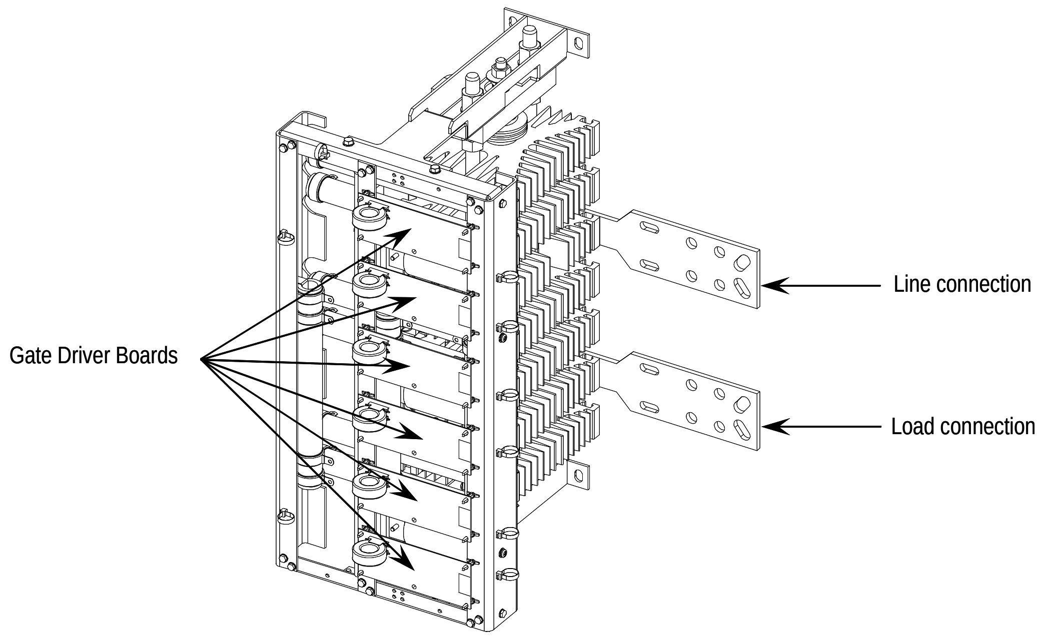


Figure 9.11 – Power Module Assembly (one phase) • 5500/6900 V, 180/360 A

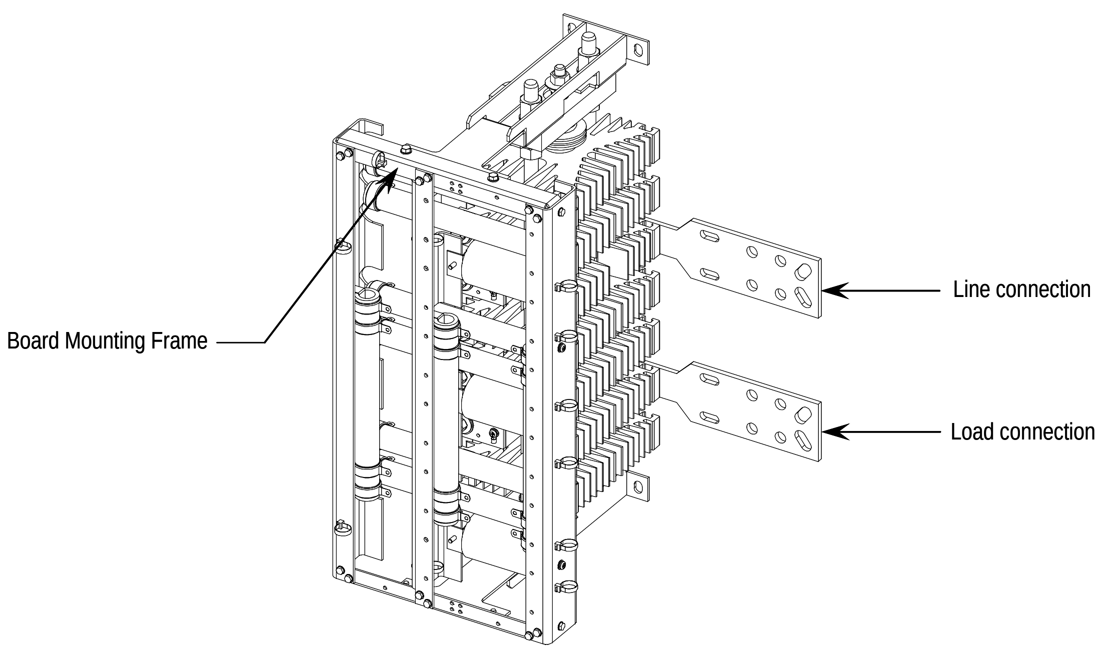


Figure 9.12 – Power Module Assembly (one phase) with Gate Driver Boards Removed • 5500/6900 V, 180/360 A

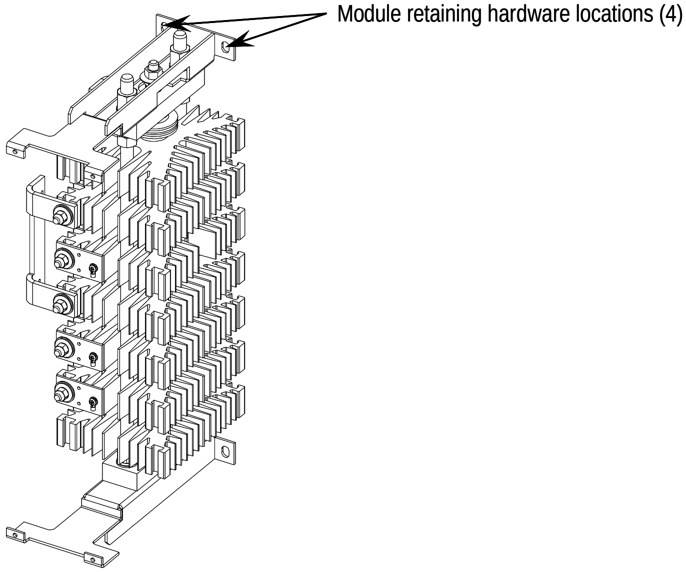


Figure 9.13 – Power Module Assembly (one phase) with Boards and Frame Removed • 5500/6900 V, 180/360 A

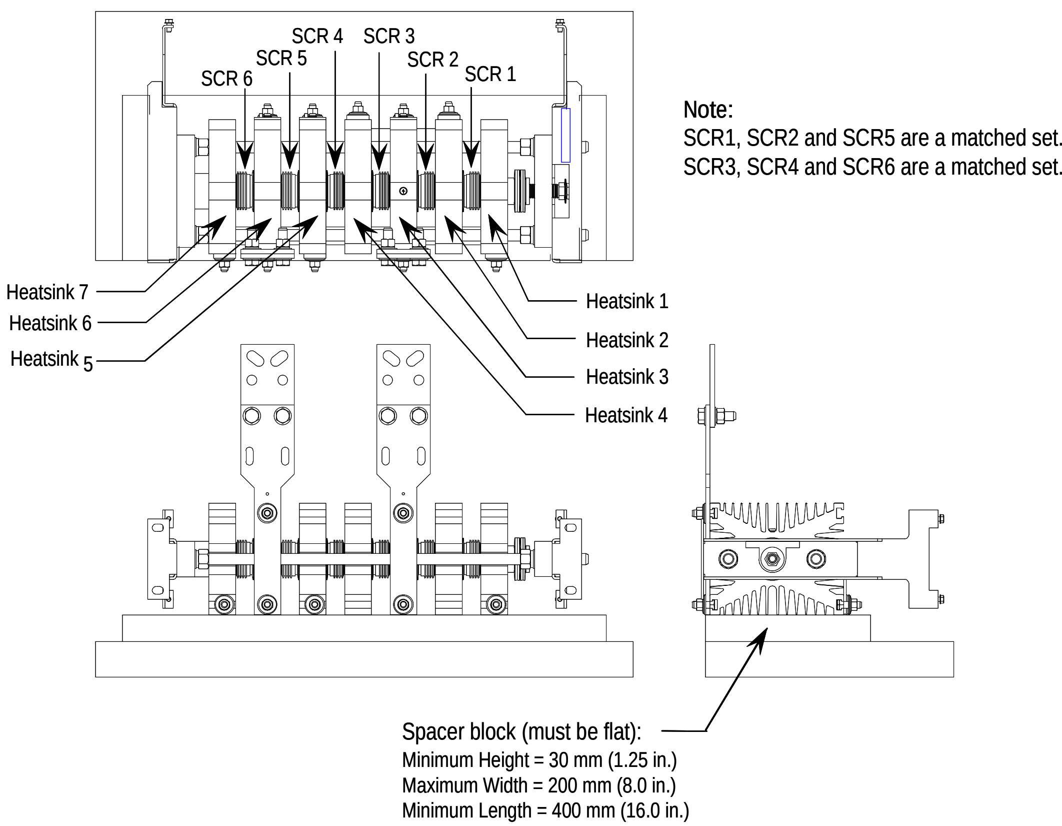


Figure 9.14 – 6900V Heatsink Assembly, 180/360 A
Positioned on bench for SCR replacement

To remove clamp pressure, loosen lower center nut so that the gap between the clamp surface and the heatsink is approximately 6 mm (0.25 inch).
A 21-mm open end wrench is required.

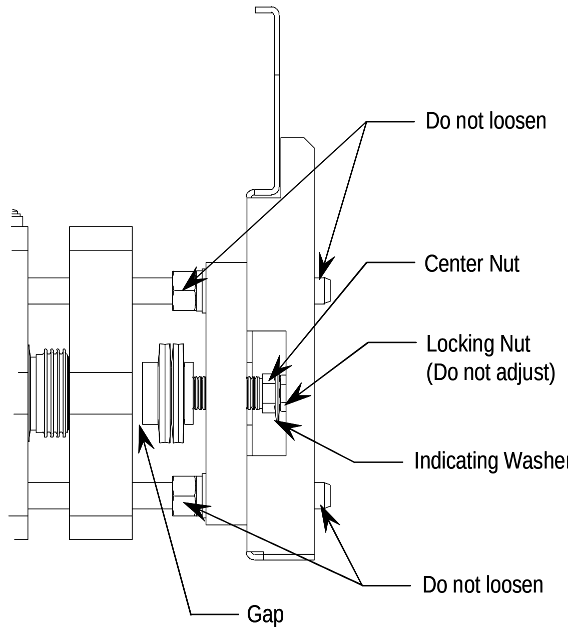


Figure 9.15 – 6900V SCR Replacement, 180/360 A

To Remove SCR1:
- Remove shorting bar hardware
- Pry Heatsinks 1 and 2 apart
- Extract SCR

To Insert New SCR:
- Apply thin film of electrical joint compound to surfaces of SCR.
- Install SCR so that it is seated in locating pin of heatsink (note orientation of SCR).
- Pry heatsinks to close gap, ensuring that SCR is seated properly in both its locating pins.
- Rotate SCR so that all leads have same direction.

Proceed to replacement of other SCRs in the matched set (SCR2 and SCR5).

Note: You must replace all three SCRs of a matched set.

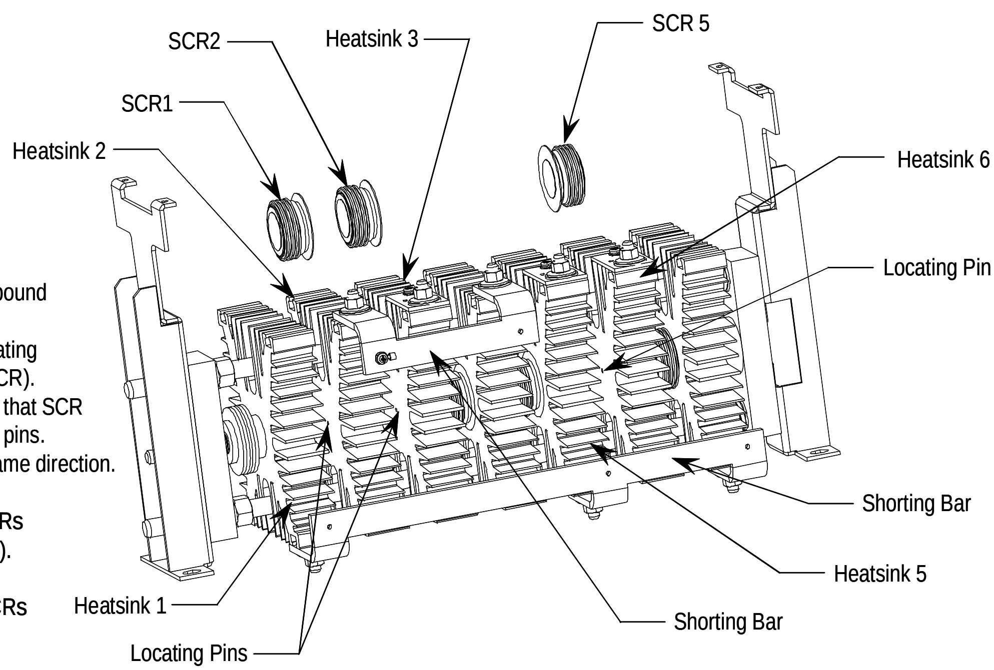


Figure 9.16 – Removing and Replacing SCR1, SCR2 and SCR5

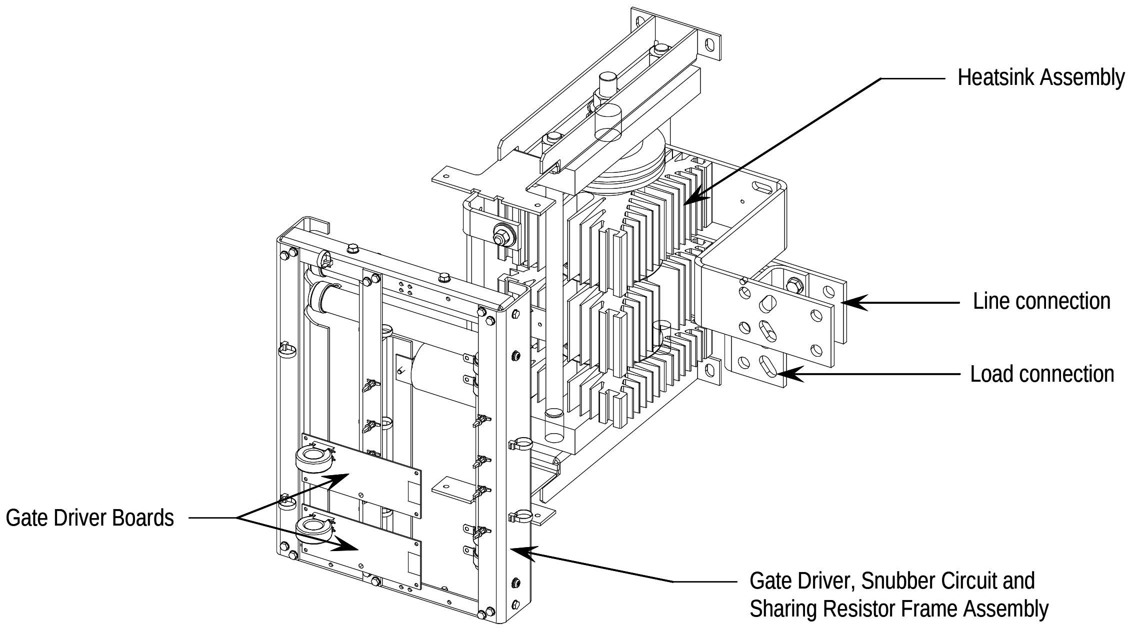


Figure 9.17 – Power Module Assembly (one phase) • 2300 V, 600 A

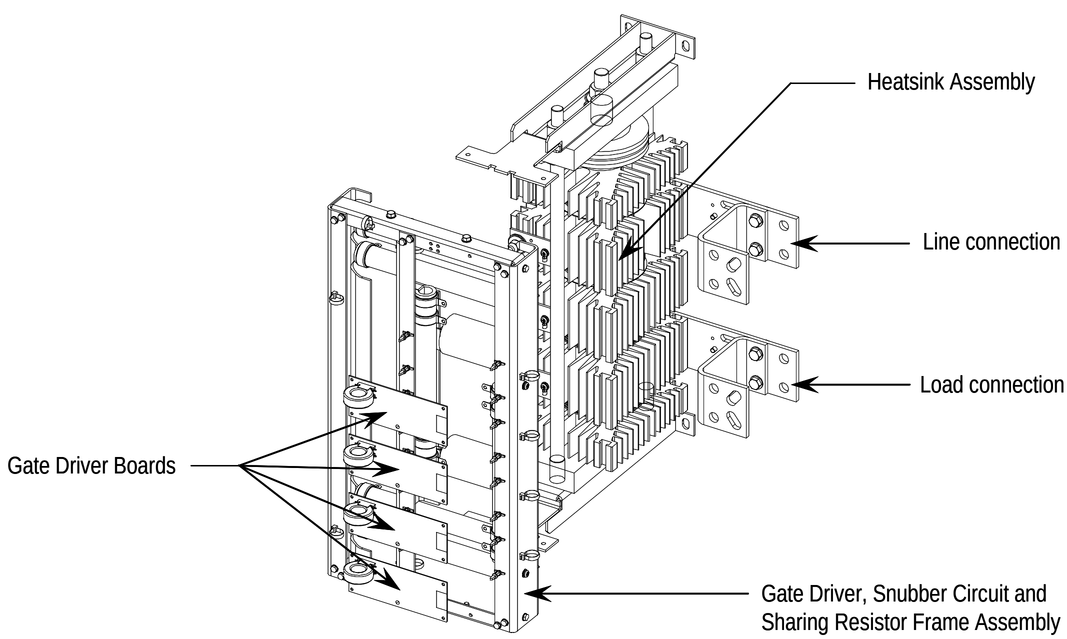


Figure 9.18 – Power Module Assembly (one phase) • 3300/4160 V, 600 A

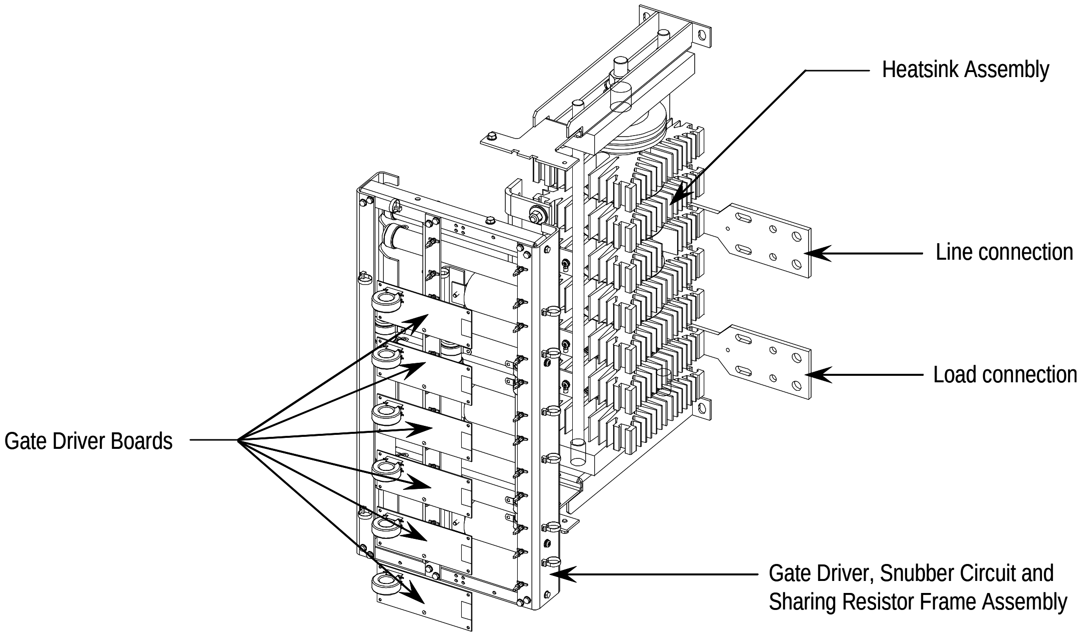


Figure 9.19 – Power Module Assembly (one phase) • 5500/6900 V, 600 A

Snubber and Resistor Circuit Testing

If the resistance checks from the Thyristor testing section were abnormal and the thyristors checked out OK, there may be a problem in the snubber or resistor circuits.

1. Remove all power from the equipment.

SHOCK HAZARD

To avoid shock hazard, ensure main power has been disconnected before working on the controller, motor or control devices. Verify that all circuits are voltage free using a hot stick or appropriate voltage measuring device. Failure to do so may result in burns, injury or death.

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2. Check the snubber components and sharing resistors by isolating them and measuring values as follows (See Figures 9.21 to 9.26):

RS	60 Ω (180 and 360A) 30 Ω (600A)
CS	0.5 or 0.68 µF (180 and 360A) 1.0 µF (600A)
RRx	32.5 kΩ total, taps at 2.5 kΩ from each end (x = 1, 2 or 3)

Replace any out-of-spec components. See Renewal Parts listing in Appendix D.

3. If the snubbers and sharing resistors are within tolerances, check the resistance of the voltage sensing module (refer to Figure 9.20). Remove the ribbon connector from J1 by pressing down on the locking tabs then gently pulling the connector out. Take note of which tap the white high voltage wires are connected to, then remove them (L1, T1, L2, T2, L3, T3). Measure the resistance between each tap and the ground connection, and compare to the values in Figure 9.20.

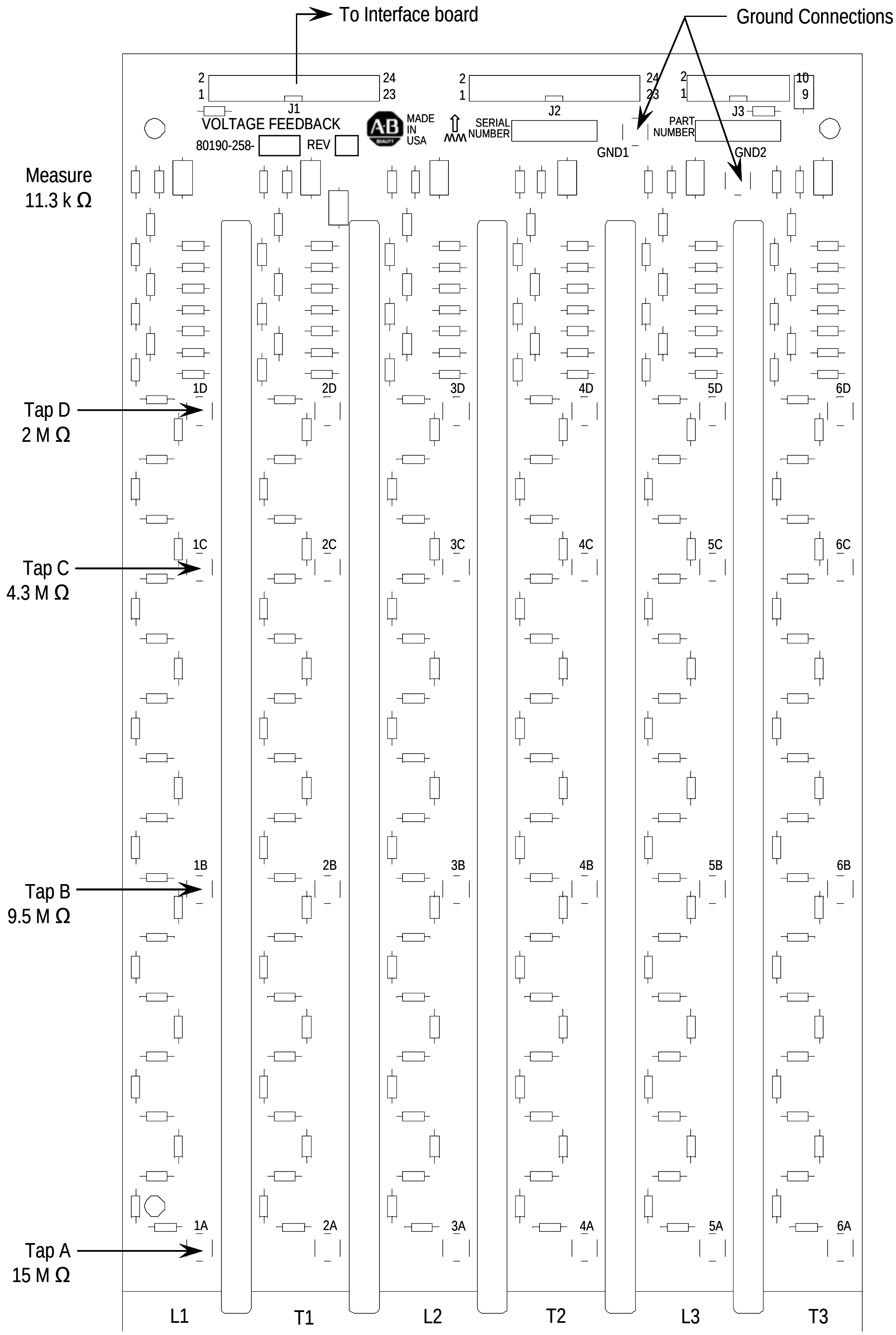

Figure 9.20 – Voltage Sensing Board

Measure across R36, R73, R110, R147, R184 and R221 located at the bottom of each leg of the module. The resistance should be 11.3 kohm. (The two ground connections **must** be connected to ground, or to each other if the module has been removed.)

If the values for each leg vary by more than 1%, the voltage sensing module may need to be replaced. See Renewal Parts listing in Appendix D, and refer to procedure on page 9-8.

ATTENTION

Grounds must be reconnected on the voltage sensing boards. Failure to do so may result in injury, death or damage to equipment.

Note: The white high voltage wires must be connected to the correct tap on each leg of the voltage sensing module. Failure to do so may result in equipment damage.

The ribbon cable must be connected to J1 only on the voltage sensing board or the equipment will not function.

4. When repairs are complete, re-assemble all parts, check all fasteners, and verify all connections are correct and tight. Make sure all barriers and mechanical parts are in place and secured.

ATTENTION

Make sure ground wires from the Voltage Sensing Module are securely connected to the ground bar in the low voltage panel. Failure to do so may result in severe injury or equipment damage.

5. Repeat Thyristor (SCR) resistance checks (page 9-12) and Power Supply Tests (page 3-7).

Snubber Resistor Replacement

When replacing the ceramic wire-wound type snubber resistors, use caution when handling the parts. The resistor element is under a thin coating on the ceramic tube, and it may be damaged if dropped, struck or scraped.

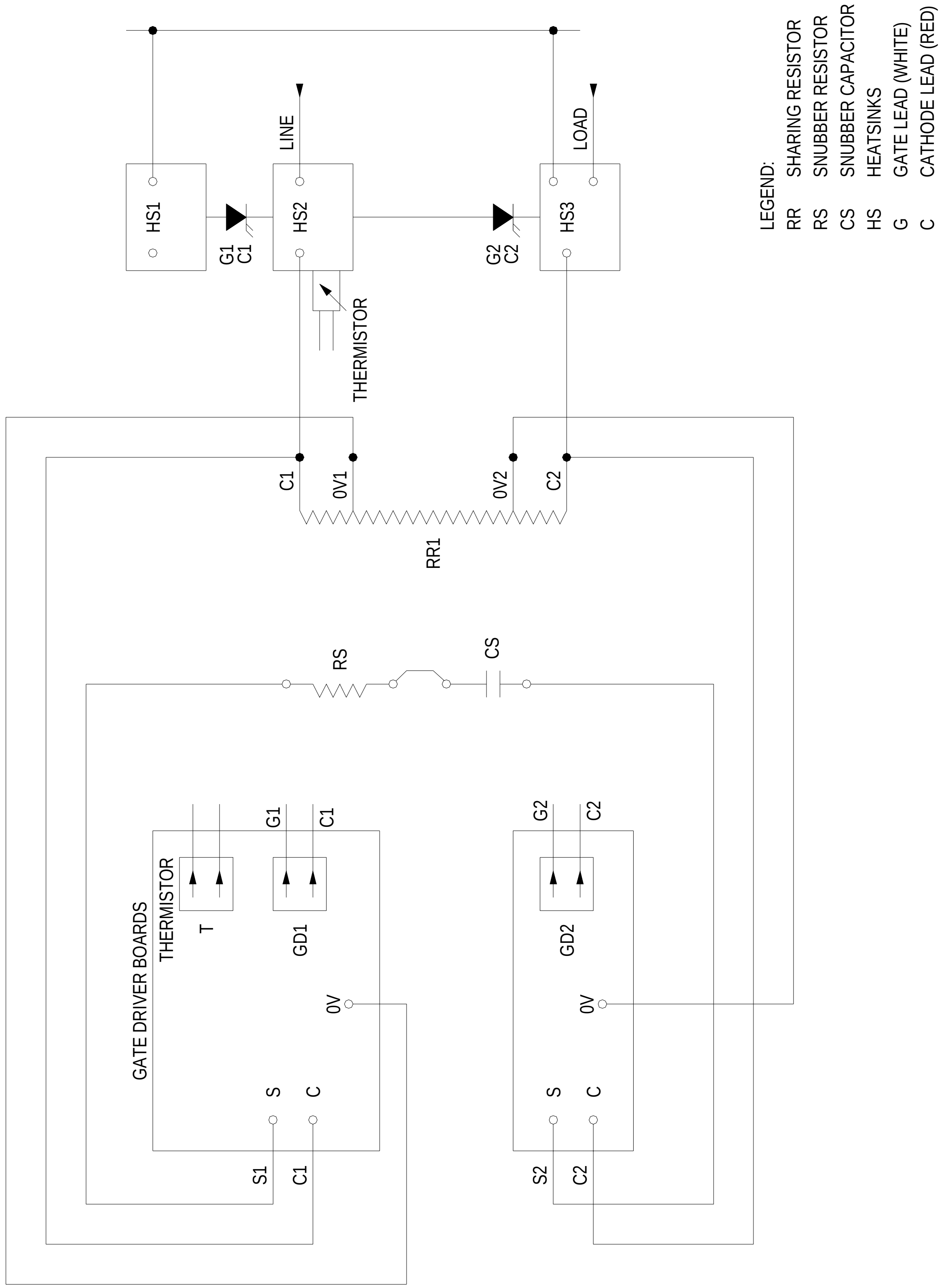

Figure 9.21 – 1500/2400 V Module Wiring (180/360 A)

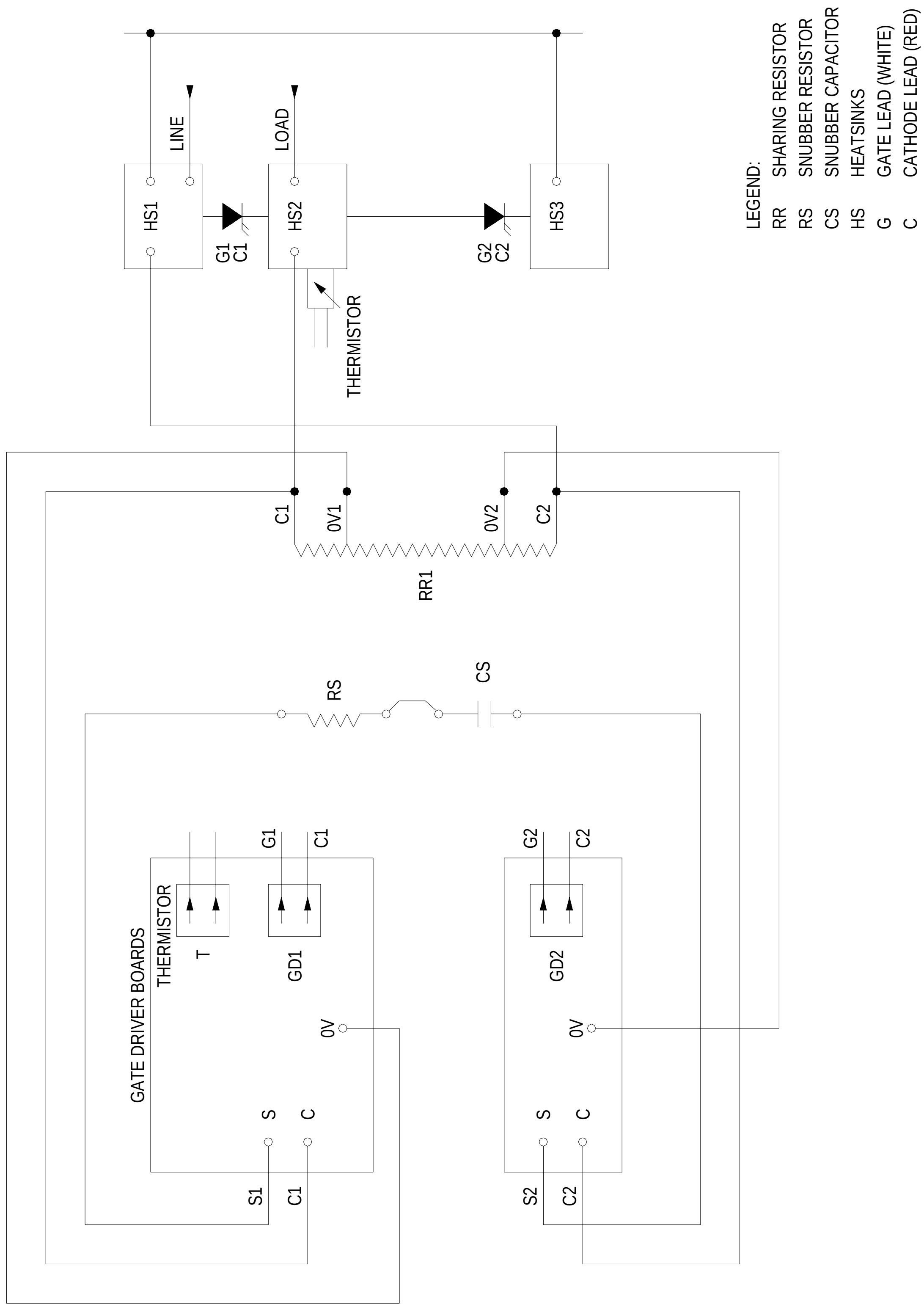

Figure 9.22 – 1500/2400 V Module Wiring (600 A)

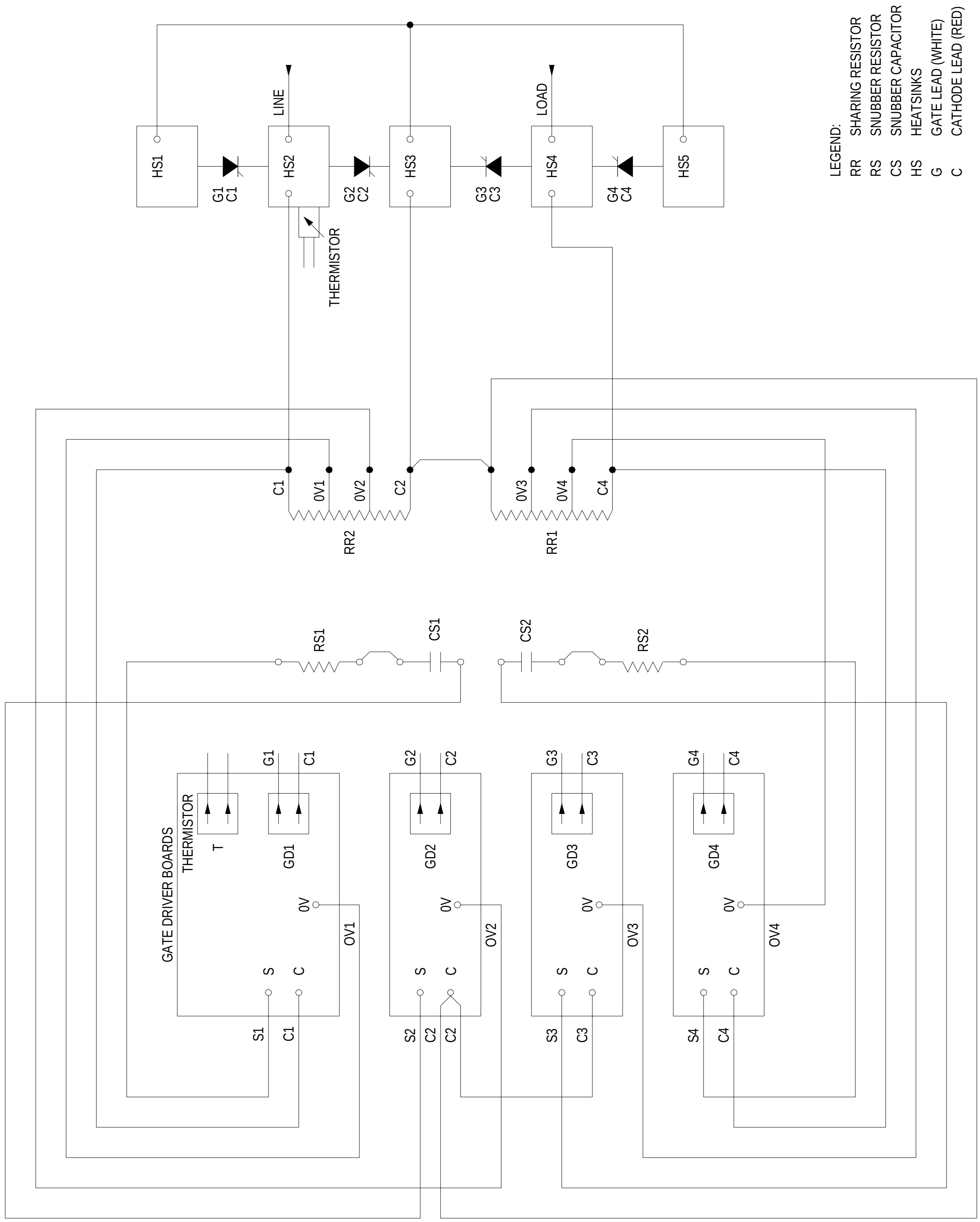

Figure 9.23 – 3300/4160 V Module Wiring (180/360/600 A)

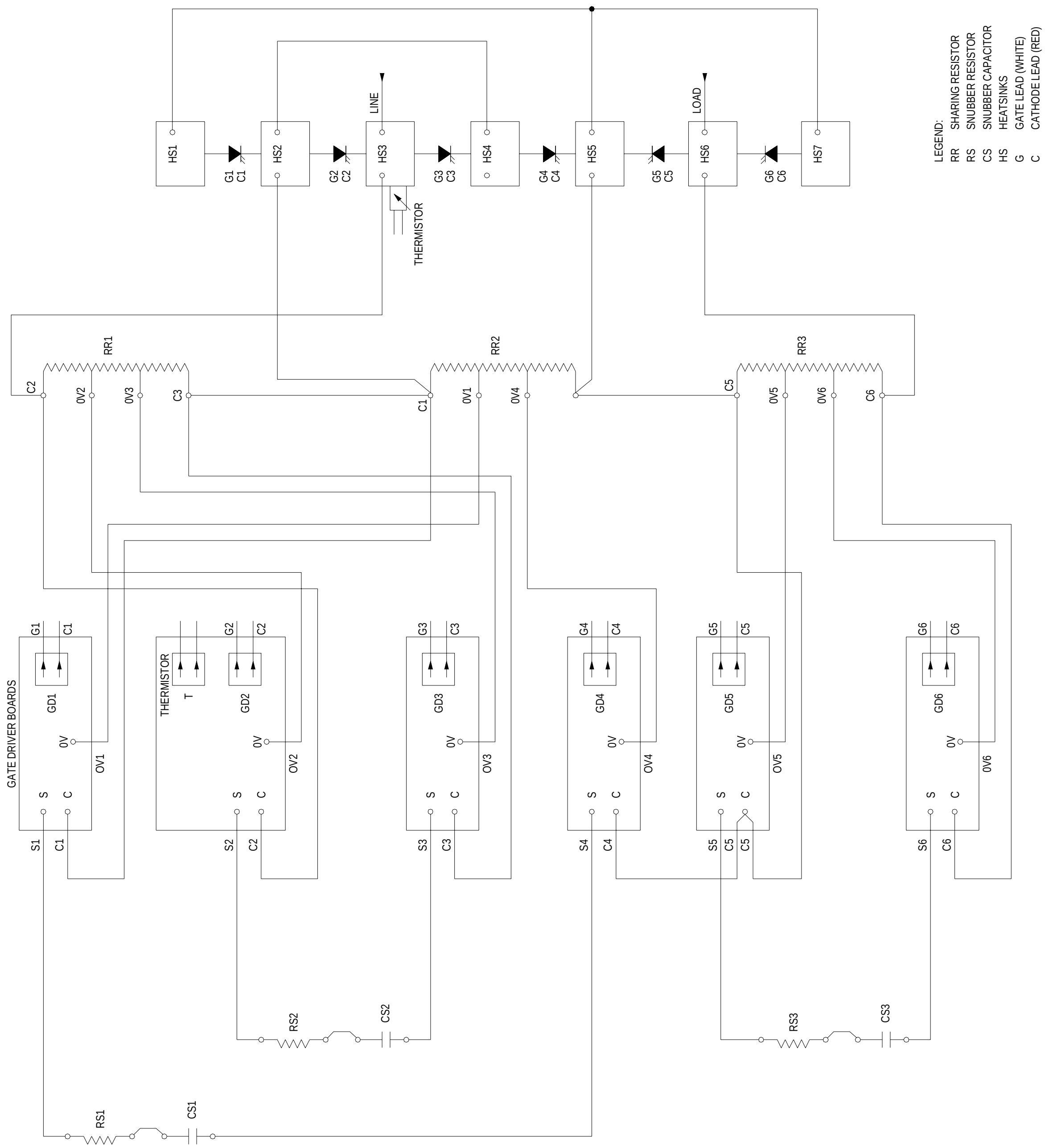

Figure 9.24 – 6900 V Module Wiring (180/360/600 A)

Chapter 10

Maintenance

Safety and Preventative

The Maintenance Technician should become familiar with the layout and be aware of the basic system parameters. Only qualified technicians should be allowed to work with this equipment under competent supervision.

General housekeeping is the key to maintaining power electronic and electrical equipment. They are to be kept as dust free as possible. A scheduled program of inspection will reduce the possibility of problems.

ATTENTION

Servicing energized industrial control equipment can be hazardous. Severe injury or death can result from electrical shock, burn, or unintended actuation of controlled equipment. Recommended practice is to disconnnect and lock out control equipment from power sources, and allow any stored energy in capacitors to dissipate. If it is necessary to work in the vicinity of energized equipment, the safety related work practices of NFPA 70E, Electrical Safety Requirements for Employee Workplaces, must be followed.

Periodic Inspection

Note: For OEM-supplied components, refer to documentation provided by the OEM for recommended periodic maintenance procedures.

Industrial control equipment should be inspected periodically. Inspection intervals should be based on environmental and operating conditions, and adjusted as indicated by experience. An initial inspection, within 3 or 4 months after installation, is suggested. Applicable parts of the following guidelines should be used:

Contamination

If inspection reveals that dust, moisture or other contamination has reached the control equipment, the source must be eliminated. This could indicate an incorrect or ineffective enclosure, unsealed enclosure openings (conduit or other) or incorrect operating procedures. Dirty, wet or contaminated parts must be replaced unless they can be cleaned effectively by vacuuming or wiping.

Periodic Inspection (cont.)

ATTENTION

Allen-Bradley magnetic starters, contactors and relays are designed to operate without lubrication – do **not** lubricate these devices since oil or grease on the pole face (mating surfaces) of the operating magnet may cause the device to stick in the "ON" mode. Erratic operation can result with injury or death.

Some parts of other devices are factory lubricated – if lubrication during use or maintenance of these devices is needed, it will be specified in their individual instructions. If in doubt, consult the nearest Rockwell Automation sales office for information.

Vacuum Bottles

The contacts in a vacuum bottle cannot be seen or examined directly. They rely on the high vacuum to operate properly and to interrupt current. Visually inspect the wear of the main contacts with the contacts closed. When any part of the wear indicator, located on the front side of the hex shaft, moves up into the bearing, replace all three vacuum bottles (see Vacuum Contactor User Manual).

The vacuum level should be tested periodically by applying high voltage alternating current across the open bottle using a vacuum tester or Hi-Pot equipment (see Vacuum Contactor User Manual).

Terminals

Loose connections can cause overheating that can lead to equipment malfunction or failure. Check the tightness of all terminals and bus bar connections and securely tighten any loose connections. Replace any parts or wiring damaged by overheating.

Coils

If a coil exhibits evidence of overheating (cracked, melted or burned insulation), it must be replaced. In that event, check for and correct overvoltage or undervoltage conditions, which can cause coil failure. Be sure to clean any residues of melted coil insulation from other parts of the device or replace such parts.

Solid-State Devices

Solid-state devices require little more than a periodic visual inspection. Printed circuit boards should be inspected to determine whether all cables are properly seated in their connectors. Board locking tabs should also be in place. Necessary replacements should be made only at the PC board or plug-in component level. Solvents should not be used on printed circuit boards. Where blowers are used, air filters, if supplied, should be cleaned or changed periodically depending on the specific environmental conditions encountered. For additional information see NEMA Standards Publication No. ICS 1.1 - 1987 entitled "Safety Guidelines for the Application, Installation and Maintenance of Solid State Control".

ATTENTION

Use of other than factory recommended test equipment for solid-state controls may result in damage to the control or test equipment, or unintended actuation of the controlled equipment.

Static-Sensitive Items

While performing maintenance on the MV SMC, special precautions must be observed in handling or touching certain static-sensitive components in the cabinet. Most circuit cards and SCRs can be damaged by Electro-Static Discharge (ESD). If personnel will make contact with an ESD-sensitive component during maintenance, they must be grounded. Grounding should be accomplished with a wrist strap which is connected to an approved ground.

Overload Maintenance After a Fault Condition

See NEMA Standards Publication No. ICS 2 Appendix A entitled "Maintenance of Motor controllers after a fault condition".

Final Check Out

After maintenance or repair of industrial controls, always test the control system for proper functioning under controlled conditions that avoid hazards in the event of a control malfunction.

Periodic Inspection (cont.)

"Keep Good Maintenance Records"

This rule will be most helpful in locating possible intermittent problems by pointing to a particular area of recurring trouble within the overall system. Furthermore, good maintenance records will help reduce major, costly shutdowns by demanding the use of proper test equipment and an appropriate inventory of spare parts. For additional information see NFPA 70B, "RECOMMENDED PRACTICE FOR ELECTRICAL EQUIPMENT MAINTENANCE", published by the National Fire Protection Association.

Power Components

Power components should be kept clean and free of dirt and obstructions. This will avoid tracking and heat build-up, thereby increasing the life of the device.

Control Components – Electronic

The printed circuit boards are to be kept clean and free of any accumulations of dirt and foreign materials.

Materials which create static electricity should never be allowed near circuit boards while in the unit, or in storage. Caution should be used when one is near or handling circuit boards. There are no other requirements, other than housekeeping standards, that the maintenance program requires on the logic control components.

Fans

Physically rotating and observing the fans for noise or binding will indicate if fan failure is evident.

Interlocks

Verify that interlocks function as intended, and have not been forced, damaged or removed.

Barriers

Verify that all barriers are in place and securely fastened.

Environmental Considerations

Hazardous materials

Environmental protection is a top priority for Rockwell Automation. The facility that manufactured this medium voltage product operates an environmental management system that is certified to the requirements of ISO 14001. As part of this system, this product was reviewed in detail throughout the development process to ensure that environmentally inert materials were used wherever feasible. A final review has found this product to be substantially free of hazardous material.

Please be assured that Rockwell Automation is actively seeking alternatives to potentially hazardous materials for which no feasible alternatives exist today in the industry. In the interim, the following precautionary information is provided for your protection and for the protection of the environment. Please contact the factory for any environmental information on any material in the product or with any general questions regarding environmental impact.

- Capacitor Dielectric Fluid

  The fluids used in the snubber capacitors are generally considered very safe and are fully sealed within the capacitor housings. Shipping and handling of this fluid are typically not restricted by environmental regulations. In the unlikely event that capacitor fluid leaks out, avoid ingestion or contact with skin or eyes as slight irritation could result. Rubber gloves are recommended for handling.

  To clean up, soak into an absorbent material and discard into an emergency container. Do not dispose into any drain or into the environment in general or into general landfill refuse. Dispose of according to local regulations. If disposing of an entire capacitor, the same disposal precautions should be taken.

- Printed Circuit Boards

  Printed circuit boards may contain lead in components and materials. Shipping and handling of these boards are typically not restricted by environmental regulations, however, lead is considered a hazardous substance. Circuit boards must be disposed of according to local regulations and must not be disposed of with general landfill refuse.

Environmental Considerations (cont.)

- Chromate Plating

  Sheet steel and fasteners may be plated with zinc and sealed with a chromate-based dip (gold- or silver-coloured finish). Shipping and handling of chromate plated parts are typically not restricted by environmental regulations, however, chromate is considered a hazardous substance. Chromate plated parts must be disposed of according to local regulations and must not be disposed of with general landfill refuse.

- In Case Of Fire

  This product is highly protected against arcing faults and therefore it is very unlikely it would be the cause of a fire. In addition, the materials used are self-extinguishing (i.e. they will not burn without a sustained external flame). If, however, the product is subjected to a sustained fire from some other source, some of the polymer materials will produce toxic gases. As with any fire, individuals involved in extinguishing the fire or anyone in close proximity should wear a self-contained breathing apparatus to protect against any inhalation of toxic gases.

Disposal

When disposing of the product, it should be disassembled and separated into groups of recyclable material as much as possible (i.e. steel, copper, plastic, wire, etc.). These materials should then be sent to local recycling facilities. In addition, all disposal precautions mentioned above must also be taken for those particular materials.

1560E/1562E SMC-Flex Specifications

Table A.1 – Specifications

Electrical Ratings	UL/CSA/NEMA	IEC
Power Circuit		
Method of Connection	Motor in delta or star; SCRs between windings and supply	
Number of Poles	Equipment designed for three phase loads only	
Rated Voltage (Ur)	2400 V AC (-15%, +10%) 3300 V AC (-15%, +10%) 4200 V AC (-15%, +10%) 6900 V AC (-15%, +10%)	3.6 kV 7.2 kV
Rated Insulation Voltage (Ui)	2500 V 5000 V 7200 V	3.6 kV 7.2 kV
Rated Impulse Voltage (Uimp)	60 kV	(3.6 kV) 40 kV (7.2 kV) 60 kV
Dielectric Withstand	(2500 V) 7,625 V AC (5000 V) 13,250 V AC (7200 V) 18,200 V AC	(3.6 kV) 10 kV (7.2 kV) 20 kV
Repetitive Peak Inverse Voltage Rating	2500 V max. 6,500 V (2 SCRs per phase) 5000 V max. 13,000 V (4 SCRs per phase) 7200 V max. 19,500 V (6 SCRs per phase)	
Output Rating	100 to 7500 hp	75 to 5600 kW
Semi-Conductor Isolation	Fiber optic	
Operating Frequency	50/60 Hz	50/60 Hz
dv/dt Protection	RC Snubber Network	
Transient Protection	Integrated overvoltage trigger circuit	
Rated Current	180 A 360 A 600 A	
dv/dt	180 A 1000 V/µs 360/600 A 2000 V/µs	
di/dt	180/360/600 A 200 A/µs	
Voltage Drop (Line to Output Terminals)	2.5 V per SCR without bypass; Less than 1.0 V with bypass, total	
Overall Efficiency	99.95% with bypass	
Starting Torque	0 to 90% of motor torque	
Thermal Capacity	600%, 10 seconds 450%, 30 seconds	
Ramp Time	0 to 30 seconds (Consult Factory for Longer Time)	
Acceleration Kick	550% for 0.0 to 2.0 seconds	
Approvals	UL E102991 CSA LR12235 (pending)	Safety : 92/59/EEC (Directive) TI/061/1198 (Certificate) Ref : BSEN 61010-1 :1993 BSEN 60204-1 :1997 EMC : 89/336/EEC, 92/31/EEC, 93/68/EEC (Directives) T703ALB1 (Certificate) Ref : EN 61000-6.4 :2001 EN 61000-6.2 :2001

Table A.1 – Specifications (cont.)

Electrical Ratings (cont.)	UL/CSA/NEMA	IEC
Short Circuit Protection		
The power electronics unit must be protected by current-limiting fuses (to be included by customer in existing starter with 1560E). The combination controller includes appropriate fusing (coordinated with motor).		
Fault Level Withstand as a Fused (E2) Controller NEMA E2	2400 V 4160 V 4600 V 6900 V	200 MVA Sym 350 MVA Sym 400 MVA Sym 570 MVA Sym
Control Circuit		
Rated Operation Voltage	120/240 V AC (-15%, +10%)	110/230V ~ (-15%, +10%)
Dielectric Withstand	1600 V AC	2000 V ~
Operating Frequency	50/60 Hz	50/60 Hz
Enclosure		
Enclosure Type	NEMA Type 1, 1G, 12 and 3R	IP 10, 21, 52 and 34
Overload Characteristics (Control Module)		
Type	Solid-state thermal overload with phase loss	
Current Range	1.0 – 2200 Amps	
Trip Classes	10, 15, 20 and 30	
Trip Current Rating	120% of Motor FLC	
Number of Poles	3	
Power Requirements		
Control Module	75 VA	
Gate Driver Boards	Self-powered ❶	
Contactor	See Contactor Specifications	
Auxiliary Contacts (Control Module)		
Rated Operation Voltage (Max.)	20-265 V AC 5-30 V DC (resistive)	20-265 V ~ 5-30 V DC (resistive)
Rated Insulation Voltage	N/A	277 V ~
Operating Frequency	50/60 Hz, DC	50/60 Hz, DC
Utilization Category	B300 30 VDC @ 0.88A pilot duty	AC-15 DC-12
Mechanical Ratings (Control Module)		
Terminals	Control Terminals : M 3.5 x 0.6 Pozidriv screw with self-lifting clamp plate	
SCPD Performance	Type 2	
SCPD List	Class CC 8A @ 1000 A Available Fault Current	
DPI Communication (Control Module)		
Maximum Output Current	280 mA	
Metering Functionality (Control Module)		
Voltage, Current, MW, MWh, Displacement Power Factor	Yes	
Tachometer Input (Control Module)		
Voltage	0 – 4.5 VDC	
Current	1.0 mA	

❶ For stop maneuvers, the gate driver boards are pre-charged with a current loop power supply (30 VA).

Table A.1 – Specifications (cont.)

Environmental Ratings	UL/CSA/NEMA	IEC
Operating Temperature Range	0°C to 40°C (32°F to 104°F)	
Storage and Transportation Temperature Range	-20°C to +75°C (-4°F to 149°F)	
Altitude	0 - 1000 meters (3,300 feet) without derating ❷	
Humidity	5% to 95% (non condensing)	
Pollution Degree	2	
Seismic (UBCRating) ❶	1, 2, 3, 4	

❶ Some units may require special bracing. Contact factory for more information.
❷ Starter Deratings are in Table A.2.

Table A.2 – Altitude Derating

Altitude Range	Power Cell Rating ❶			Reduce B.I.L. Withstand Rating By:
	180 A	360 A	600 A	
	Reduce Max. Continuous Current Rating by:			
1,000 to 2,000 m (3,300 to 6,600 ft)	10 A	10 A	15 A	6.0 kV
2,001 to 3,000 m (6,601 to 9,900 ft)	20 A	20 A	30 A	12.0 kV
3,001 to 4,000 m (9,901 to 13,200 ft)	30 A	30 A	45 A	18.0 kV
4,001 to 5,000 m (13,201 to 16,500 ft)	40 A	40 A	60 A	24.0 kV

❶ Current deratings shown are the minimum levels. Additional derating may be required due to power fuse limitations. Please consult factory for additional details.

Table A.3 – Area Available for Cable Entry/Exit

Structure Code	Voltage	Top		Bottom	
		Line	Load	Line	Load
14.60	2300 – 4160 V	5.68 X 9.00 (144 X 229)	Combined with line	5.68 X 9.00 (144 X 229)	Combined with line
14.62	6900 V	5.68 X 12.55 (144 X 319)	Combined with line	5.68 X 12.55 (144 X 319)	Combined with line
14.64	All	5.68 X 12.55 (144 X 319)	Combined with line	5.68 X 12.55 (144 X 319)	Combined with line
14.70	2300 – 4160 V	5.68 X 5.68 (144 X 144)	5.68 X 9.00 (144 X 229)	5.68 X 9.00 (144 X 229)	5.68 X 9.00 (144 X 229)
14.72	6900 V	5.68 X 9.00 (144 X 229)	5.68 X 9.00 (144 X 229)	5.68 X 5.68 (144 X 144)	5.68 X 9.00 (144 X 229)
14.74	2300 – 4160 V	5.68 X 9.00 (144 X 229)	5.68 X 9.00 (144 X 229)	5.68 X 9.00 (144 X 229)	5.68 X 9.00 (144 X 229)
14.76	All	5.68 X 9.00 (144 X 229)	7.25 X 15.88 (184 X 403)	5.68 X 9.00 (144 X 229)	7.25 X 15.88 (184 X 403)

Dimensions are in inches (mm).

Table A.4 – Cable Quantity and Size

Bulletin	Size	Structure Code	Unit Size Inches (mm)	Max. No. & Size of Incoming cables-no bus	Max. No. & Size of Incoming Cables-w/bus	Max. No. & Size of Exiting Load Cables
1560E	200/400A	14.60	26 W X 91 H (660 X 2311)	(1) 500/ (2) 250mcm/phase	(1) 500/ (2) 250mcm/phase	(1) 500/ (2) 250mcm/phase
1560E	200/400A	14.62	36 W X 91 H (914 X 2311)	(1) 500/ (2) 250mcm/phase	(1) 500/ (2) 250mcm/phase	(1) 500/ (2) 350mcm/phase
1560E	600A	14.64	44 W X 91 H (1118 X 2311)	(1) 500/ (2) 250mcm/phase	(1) 500/ (2) 250mcm/phase	(1) 500/ (2) 350mcm/phase
1562E	200/400A	14.70	36 W X 91 H (914 X 2311)	(1) 500/ (2) 250mcm/phase	(1) 750/ (2) 500mcm/phase	(1) 500/ (2) 350mcm/phase
1562E	200/400A	14.72	62 W X 91 H (1575 X 2311)	(1) 500/ (2) 250mcm/phase	(1) 500/ (2) 250mcm/phase	(1) 500/ (2) 250mcm/phase
1562E	600A	14.74	80 W X 91 H (2032 X 2311)	(1) 750mcm/phase	(1) 750/ (2) 500mcm/phase	(1) 500/ (2) 350mcm/phase
1562E	600A	14.76	100 W X 91 H (2540 X 2311)	(1) 750mcm/phase	(1) 750/ (2) 500mcm/phase	(1) 1000/ (2) 750/ (4) 500mcm/phase

Notes:

1. Restrictions based upon single conductor cable.
2. Please contact factory for multiple conductors, shielded, or other specialized cables.
3. Please contact factory if the maximum number/size needs to be exceeded. We can accommodate special requests by incorporating landing pads (if room is available) or cable terminating units.
4. The customer is responsible to size the cables and conduits in accordance with applicable installation codes.

Table A.5 – Shipping Weights and Dimensions ❶

Current Rating	Horsepower (kW)					Dimensions in inches (mm)			Shipping Weight	
	2400 V	3300 V	4200 V	6600 V	6900 V	Width	Depth	Height	lb	kg
Bulletin 1560E										
200 A	800 (600)	1000 (746)	1250 (933)	–	–	26 (660)	36 (914)	91 (2315)	800	363
400 A	1500 (1119)	2250 (1679)	2750 (2051)	–	–					
Bulletin 1560E										
200 A	–	–	–	2250 (1678)	2500 (1865)	36 (914)	36 (914)	91 (2315)	1220	554
400 A	–	–	–	4500 (3357)	5000 (3730)					
600 A	2750 (2051)	4000 (2984)	4500 (3357)	7500 (5595)	7500 (5595)	44 (1117)	36 (914)	91 (2315)	1330	590
Bulletin 1562E										
200 A	800 (600)	1000 (746)	1250 (932)	–	–	36 (914)	36 (914)	91 (2315)	1400	636
400 A	1500 (1119)	2250 (1679)	2750 (2051)	–	–					
Bulletin 1562E										
200 A	–	–	–	2250 (1676)	2500 (1865)	62 (1575)	36 (914)	91 (2315)	2325	1056
400 A	–	–	–	4500 (3357)	5000 (3730)					
Bulletin 1562E										
600 A	2750 (2051)	4000 (2984)	4500 (3357)	–	–	80 (2032)	36 (914)	91 (2315)	2325	1056
	–	–	–	7500 (5595)	7500 (5595)	80 (2540)	36 (914)	91 (2315)	3000	1364

❶ Weights and dimensions are approximate. Certain options (such as PFCC) will change weight and dimensions. Contact factory for certified dimensions and weights.

Table A.6 – Power Bus and Ground Bus

Description	Specifications	
Main Horizontal Power Bus		
Bus Bar Material	Tin-plated copper	
Optional Bus Bar Material	Silver-plated copper	
Continuous Current Rating at 40°C (104°F)	1200, 2000 and 3000 A	
Maximum Full Load Temperature Rise	65°C (149°F)	
Maximum Full Load Temperature	105°C (221°F)	
Fault Withstand Current Rating (4.5 Cycles)	60 kA RMS SYM (96 kA ASYM)	
Type of Bus Bracing	Molded glass polyester Anti-hygroscopic	
Dimensions per Phase	1200 A 2000 A 3000 A	Qty 1 – 6 x 100 mm (1/4 x 4 in) Qty 2 – 6 x 100 mm (1/4 x 4 in) Qty 2 – 9.5 x 127 mm (3/8 x 5 in)
Cross Sectional Area per Phase	1200 A 2000 A 3000 A	65 mm^2 (1.0 in^2) total 129 mm^2 (2.0 in^2) total 242 mm^2 (3.75 in^2) total
Insulating Material Between Phases and Ground	Air (Standard)	
Optional Insulation Material for Main Horizontal Bus	Type :	Sleeve, heat shrink
	Material :	Polyolefin
	Thickness :	1.4 mm (0.055 in)
	Anti-hygroscopic :	0.5 to 1%
	Electrical Strength :	900 V/mil
Vertical Power Bus		
Bus Bar Material	Tin-plated copper	
Continuous Current Rating at 40°C (104°F)	400, 600 and 800 A	
Fault Withstand Current Rating (½ cycle)	50 kA RMS SYM (80 kA ASYM)	
Insulation Material for Vertical Bus	Type :	Sleeve, heat shrink
	Material :	Polyolefin
	Thickness :	1.14 mm (0.045 in)
	Anti-hygroscopic :	0.5 to 1%
	Electrical Strength :	900 V/mil
Ground Bus		
Ground Bus Material	Bare copper	
Optional Ground Bus Material	Tin-plated copper	
Continuous Current Rating at 40°C (104°F)	600 A	
Dimensions per Phase	600 A	6 x 51 mm (1/4 x 2 in)
Cross Sectional Area	600 A	32 mm^2 (0.5 in^2) total

Table A.7 – Power Fuses and Losses

<table>
<tr><th>Description</th><th colspan="5">Specifications</th></tr>
<tr><td colspan="6">Power Fuses and Fuse Holders</td></tr>
<tr><td colspan="6">This section details the power fuse and fuse holder technical information that each medium voltage product conforms to. It includes information on R-rated fuses, as well as mounting dimensions.</td></tr>
<tr><td colspan="6">Fuse Types</td></tr>
<tr><td>R Rated : 2R to 24R
2R to 24R
19R, 38R
Interrupting Ratings : 2.4 kV to 7.2 kV</td><td colspan="5">A480R – 5.0/2.4 kV
A072 – 7.2 kV
A051B – 5.0/2.4 kV
50 kA RMS SYM (80 kA RMS ASYM)</td></tr>
<tr><td colspan="6">Mounting (Center) Dimensions</td></tr>
<tr><td>Clip-On</td><td colspan="5">304.8 mm (12.0 in)</td></tr>
<tr><td>Bolt-On</td><td colspan="5">454.2 mm (17.88 in)</td></tr>
<tr><td colspan="6">Maximum Heat Dissipation (kW) (Convection)</td></tr>
<tr><td rowspan="5">Controller Rating</td><td colspan="4">Start or Stop Cycle
(@ 450% Starting Duty)</td><td rowspan="2">Continuous</td></tr>
<tr><td></td><td>180 A</td><td>360 A</td><td>600 A</td></tr>
<tr><td>2500 V</td><td>13.5</td><td>19.2</td><td>45.3</td><td>.250</td></tr>
<tr><td>5000 V</td><td>27.0</td><td>38.5</td><td>90.5</td><td>.250</td></tr>
<tr><td>7200 V</td><td>40.5</td><td>57.7</td><td>136.0</td><td>.250</td></tr>
<tr><td colspan="6">Power Losses</td></tr>
<tr><td rowspan="6">Power Cell Losses</td><td colspan="2">Current (A)</td><td colspan="2">Fuse Size</td><td>Losses (kW)
± 10%</td></tr>
<tr><td colspan="2">90</td><td colspan="2">6R</td><td>.125</td></tr>
<tr><td colspan="2">180</td><td colspan="2">12R</td><td>.350</td></tr>
<tr><td colspan="2">240</td><td colspan="2">18R</td><td>.510</td></tr>
<tr><td colspan="2">360</td><td colspan="2">24R</td><td>1.000</td></tr>
<tr><td colspan="2">600</td><td colspan="2">57X</td><td>1.500</td></tr>
<tr><td rowspan="4">Power Bus Losses</td><td colspan="3">Bus Rating (A)</td><td colspan="2">Fully Loaded Bus Losses per 915 mm (36 in.) Section
(Watts) ±%</td></tr>
<tr><td colspan="3">1200</td><td colspan="2">150</td></tr>
<tr><td colspan="3">2000</td><td colspan="2">200</td></tr>
<tr><td colspan="3">3000</td><td colspan="2">200</td></tr>
<tr><td>Control Power Transformer Losses</td><td colspan="5">The losses from a 500 VA control power transformer fully loaded are approximately 50 W per controller.</td></tr>
<tr><td>Low Voltage Panel Losses</td><td colspan="5">The losses from the standard control circuit are approximately 25 W per controller.</td></tr>
</table>

Table A.8 – Control Wire and Power Wire

Description	Specifications
Control Wire	
All Medium Voltage structures shall be equipped with control wire which meets the following specifications:	
Type	TEW, Stranded Copper Wire (Tinned)
AWG Size (Control Circuit)	#14 AWG – 1.5 mm^2
AWG Size (Current Transformer Circuit)	#12 AWG – 2.5 mm^2
Number of Strands	19
Maximum Voltage Rating	600 V
Maximum Rated Temperature	105°C (221°F)
Terminal Blocks	1492-CA1, -CA3
Power Wire	
Power wire used to feed the primary of the control power transformer or potential transformers is as follows :	
AWG Size	#8 AWG
Type	Alcatel Excelene XLPE MV90
Insulation Rating ❶	5.0 kV
Maximum Temperature Rating	90°C (194°F)
Current Loop	#6 AWG Silicone rubber AWM 50 KV DC, 150°C

The controller shall be wired with the following non-shielded, stranded wire type, based on the current ratings :

Controller Rating (Amps)	AWG Size	Type	Insulation Rating ❷	Maximum Temperature Rating
200	#2	EP-CSPE MV90	8.0 kV	90°C (194°F)
400	#4/0	EP-CSPE MV90	8.0 kV	90°C (194°F)
600	(2) x #4/0	EP-CSPE MV90	8.0 kV	90°C (194°F)

❶ For 7.2 kV rated controllers, #8 AWG — 8.0 kV EP-CSPE MV90, non-shielded stranded cable is used.

❷ For 7.2 kV rated controllers, #2 AWG, #4/0 AWG, or 350 kcmil MCM – 8.0 kV EP-CSPE MV90, non-shielded stranded cable is used.

Parameter Information

Table B.1 – Parameter List

Group	Parameter Description	Parameter Number	Units	Min / Max	Default Settings	User Settings
Metering	Volts Phase A-B	1	V			
	Volts Phase B-C	2	V			
	Volts Phase C-A	3	V			
	Current Phase A	4	A			
	Current Phase B	5	A			
	Current Phase C	6	A			
	Watt Meter	7	KW/MW			
	Kilowatt Hours	8	KWH/MWH			
	Elapsed Time	9	Hours			
	Meter Reset	10		NO ETM Reset KWH Reset	NO	
	Power Factor	11		0.00…0.99		
	Mtr Therm Usage	12	%	0…100		
	Motor Speed	13	%	0…100		
Basic Set Up	SMC Option	14		Standard Brake Pump Control		
	Motor Connection	15		Line/Delta	Line	❷
	Line Voltage	16	V	0…10000	480	
	Starting Mode	17		Full Voltage Current Limit Soft Start Linear Speed Pump Start	Soft Start	
	Ramp Time	18	SEC	0…30	10	
	Initial Torque	19	% LRT	0…90	70	
	Cur Limit Level	20	% FLC	50…600	350	
	Torque Limit	21	% LRT	0…100	90	
	Kickstart Time	22	SEC	0.0…2.0	0.0	
	Kickstart Level	23	% LRT	0…90	0	
	Option 2 Input ❶	24		Disable Preset Slow Speed Dual Ramp Fault Fault NC Network Clear Fault Emergency Run	Disable	
Dual Ramp	Starting Mode 2	25		Full Voltage Current Limit Soft Start Linear Speed	Soft Start	
	Ramp Time 2	26	SEC	0…30	10	
	Initial Torque 2	27	% LRT	0…90	70	
	Cur Limit Level 2	28	% FLC	50…600	350	
	Kickstart Time 2	30	SEC	0.0…2.0	0.0	
	Kickstart Level2	31	% LRT	0…90	0	

❶ Pump modules do not display this parameter. Default setting for MV applications is typically 'Emergency Run'.

❷ Do not set to "Delta".

Table B.1 – Parameter List (cont.)

Group	Parameter Description	Parameter Number	Units	Min / Max	Default Settings	User Settings
Basic Set Up	Stop Mode ❶	32		Disable Soft Stop Linear Speed SMB Accu-Stop	Disable	
	Stop Time	33	SEC	0…120	0	
Basic Set Up/Accu-Stop	Braking Current	35	% FLC	0…400	0	
Preset SS/Accu-Stop	Slow Speed Sel	39		SS Low SS High	SS High	
	Slow Speed Dir	40		SS FWD SS REV	SS FWD	
	Slow Speed Cur	41	% FLC	0…450	0	
	Slow Running Cur	42	% FLC	0…450	0	
Accu-Stop	Stopping Current	43	% FLC	0…400	0	
Basic Set Up / Overload	Overload Class	44		Disable Class 10 Class 15 Class 20 Class 30	Class 10	
	Service Factor	45		0.01…1.99	1.15	
	Motor FLC	46	A	1.0…1000.0	1.0	
	Overload Reset	47		Manual	Manual	
Overload	Overload A Lvl	50	% MTU	0…100	0	
Underload	Underload F Lvl	51	% FLC	0…99	0	
	Underload F Dly	52	SEC	0…99	0	
	Underload A Lvl	53	% FLC	0…99	0	
	Underload A Dly	54	SEC	0…99	0	
Undervoltage	Undervolt F Lvl	55	% V	0…99	0	
	Undervolt F Dly	56	SEC	0…99	0	
	Undervolt A Lvl	57	% V	0…99	0	
	Undervolt A Dly	58	SEC	0…99	0	
Overvoltage	Overvolt F Lvl	59	% V	0…199	0	
	Overvolt F Dly	60	SEC	0.99	0	
	Overvolt A Lvl	61	% V	0…199	0	
	Overvolt A Dly	62	SEC	0…99	0	
Unbalance	Unbalance F Lvl	63	%	0…25	0	
	Unbalance F Dly	64	SEC	0…99	0	
	Unbalance A Lvl	65	%	0…25	0	
	Unbalance A Dly	66	SEC	0…99	0	
Jam	Jam F Lvl	67	% FLC	0…1000	0	
	Jam F Dly	68	SEC	0…99	0	
	Jam A Lvl	69	% FLC	0…1000	0	
	Jam A Dly	70	SEC	0…99	0	
Stall	Stall Delay	71	SEC	0.0…10.0	0	

❶ Pump option modules default to “Pump Stop”.

Table B.1 – Parameter List (cont.)

Group	Parameter Description	Parameter Number	Units	Min / Max	Default Settings	User Settings
Ground Fault	Gnd Flt Enable	72		Disable Enable	Disable	
	Gnd Flt Level	73	A	1.0…5.0	2.5	
	Gnd Flt Delay	74	SEC	0.1…250.0	0.5	
	Gnd Flt Inh Time	75	SEC	2.25	10	
	Gnd Flt A Enable	76		Disable Enable	Disable	
	Gnd Flt A Lvl	77	A	1.0…5.0	2.0	
	Gnd Flt A Dly	78	SEC	0…250	10	
PTC	PTC Enable	79		Disable Enable	Disable	
Phase Reversal	Phase Reversal	80		Disable Enable	Disable	
Restart	Starts Per Hour	81		0…99	2	
	Restart Attempts	82		0…5	2	
	Restart Delay	83	SEC	0…60	0	
Comm Masks	Logic Mask	87		8-bit binary		
Data Links	Data In A1	88				
	Data In A2	89				
	Data In B1	90				
	Data In B2	91				
	Data In C1	92				
	Data In C2	93				
	Data In D1	94				
	Data In D2	95				
	Data Out A1	96				
	Data Out A2	97				
	Data Out B1	98				
	Data Out B2	99				
	Data Out C1	100				
	Data Out C2	101				
	Data Out D1	102				
	Data Out D2	103				
Motor Data	Motor ID	104		0…65535	0	
	CT Ratio	105		1…1500		
	MV Ratio ❶	106		1…10000		

❶ Refer to Chapter 3, Commissioning Procedures, to determine the appropriate setting.

Table B.1 – Parameter List (cont.)

Group	Parameter Description	Parameter Number	Units	Min / Max	Default Settings	User Settings
Basic Set Up	Aux 1 Config ❶	107		Normal Normal NC Up To Speed Up To Speed NC Fault Fault NC Alarm Alarm NC Network Network NC External Bypass	Up To Speed	
	Aux 3 Config	108		Normal Normal NC Up To Speed Up To Speed NC Fault Fault NC Alarm Alarm NC Network Network NC External Bypass	Alarm	
	Aux 4 Config	109		Normal Normal NC Up To Speed Up To Speed NC Fault Fault NC Alarm Alarm NC Network Network NC External Bypass	Normal	
	Aux 2 Config	110		Normal Normal NC Up To Speed Up To Speed NC Fault Fault NC Alarm Alarm NC Network Network NC External Bypass	Fault	
Language	Language	111		English French Spanish German Portuguese Mandarin	English	
All	Parameter Mgmt	115		Ready Load Default	Ready	
Basic Set Up	Backspin Timer	116	SEC	0…999	0	

❶ This parameter does not appear for MV applications.

Table B.1 – Parameter List (cont.)

Group	Parameter Description	Parameter Number	Units	Min / Max	Default Settings	User Settings
Linear List	Fault 1	124		0…255		
	Fault 2	125		0…255		
	Fault 3	126		0…255		
	Fault 4	127		0…255		
	Fault 5	128		0…255		
Basic Set Up	Option 1 Input	132		Disable Coast Stop Option Fault Fault NC Network	Stop Option	
	Stop Input	133		Coast Stop Option	Coast	

1560E and 1562E Relay Control

Functional Description

The following functional descriptions and associated control circuits are for units using electromechanical (relay) control.

Bulletin 1562E • Basic Control – Controlled Start only

When wired as shown in Figure C.1, the controller operates as follows:

Pressing the "Start" button initiates the start sequence. Relay "CR" closes and applies control power to terminal 17 of the SMC-Flex module. The auxiliary contact #2 (set for "normal") closes, picking up "MC", which completes the hold-in circuit on the start button, and closes the main contactor.

The SMC-Flex module examines the line voltage, looks for fault conditions, checks phase rotation, calculates zero crossing information, and begins gating the SCRs to start the motor.

When the motor approaches rated speed, the SMC-Flex module closes the "AUX1" (up-to-speed) auxiliary contacts, closing relay "BC", which closes the bypass contactor. The motor then runs at full line voltage.

When the "Stop" button is pressed, the "CR" relay opens terminal 17 on the SMC-Flex module. The "AUX4" (Normal) contact opens, dropping out the main contactor, allowing the motor to stop. The "AUX1" contact also opens, but "BC" is held closed for a short time by the control module. This holds the bypass contactor closed for about 10 seconds to protect the power electronics from any voltage transients due to opening the motor circuits.

Functional Description (cont.)

Bulletin 1562E • Basic Control – With Controlled Stop

When wired as shown in Figure C.2, the controller operates in much the same manner as in Figure C.1.

Terminal 16 on the SMC-Flex module now controls the start and stop maneuvers. Terminal 16 must remain energized for the module to run. When the “Stop” button is pressed, and “CR” opens, the SMC-Flex module will initiate the option stop. An uncontrolled, or coast stop, is achieved by opening the connection to terminal 17. This contact should remain open to ensure all hold-in contacts clear, to prevent a re-start.

If the motor has started, the unit is in the bypass mode, and a trip occurs within the SMC-Flex module or from an external protection relay, AUX4 will open the line contactor immediately. "AUX1" will remain closed for 10 seconds. A trip due to an overload or fault condition will result in a “coast” stop.

Bulletin 1562E • DPI Control – Controlled Start only

Refer to Figure C.3 and description on page 1-27.

Bulletin 1560E • Basic Control – Controlled Start Only

The Bulletin 1560E is intended for addition to an existing motor controller, which provides circuit isolation, motor switching, and overload and overcurrent protection. When wired as shown in Figure C.4, the controller operates as follows:

When a start is initiated in the existing motor controller and the contactor (or breaker) closes, a contact must be supplied to tell the 1560E to start also. A "CR" contact will apply control voltage to terminal 17 of the SMC-Flex module.

When stopping the motor, the contactor in the existing controller will open, removing power from the motor, and then the “CR” relay. The bypass hold-in rung will keep the bypass contactor closed for a short time.

The “Fault” contact on the SMC-Flex module should be wired into the existing controller to trip the main contactor (or breaker) in the event of a fault condition sensed by the SMC-Flex module.

If possible, it is better to have the SMC-Flex module control the main contactor directly. In this case, the control circuit would look like, and function like, the descriptions above for the Bulletin 1562E.

Bulletin 1560E • Basic control – With Controlled Stop

When wired as shown in Figure C.5, the controller operates much the same as described above for the Standard module. The control signal uses terminal 16 instead of 17, and a “coast” stop can be achieved by opening the connection to terminal 17.

It is more important in this configuration to integrate the control circuit of the 1560E with the existing controller, for better control of the Stop option. The “start signal” for this scheme cannot be a slave of the main contactor, since it must remain closed to accomplish the option stop maneuver. The SMC-Flex module can be used to control the main contactor such that it will close when a start is initiated, and remain closed until it has sensed the motor has stopped following an option stop maneuver.

Bulletin 1560E • DPI Control – Controlled Start only

Refer to Figure C.6 and description on page 1-29.

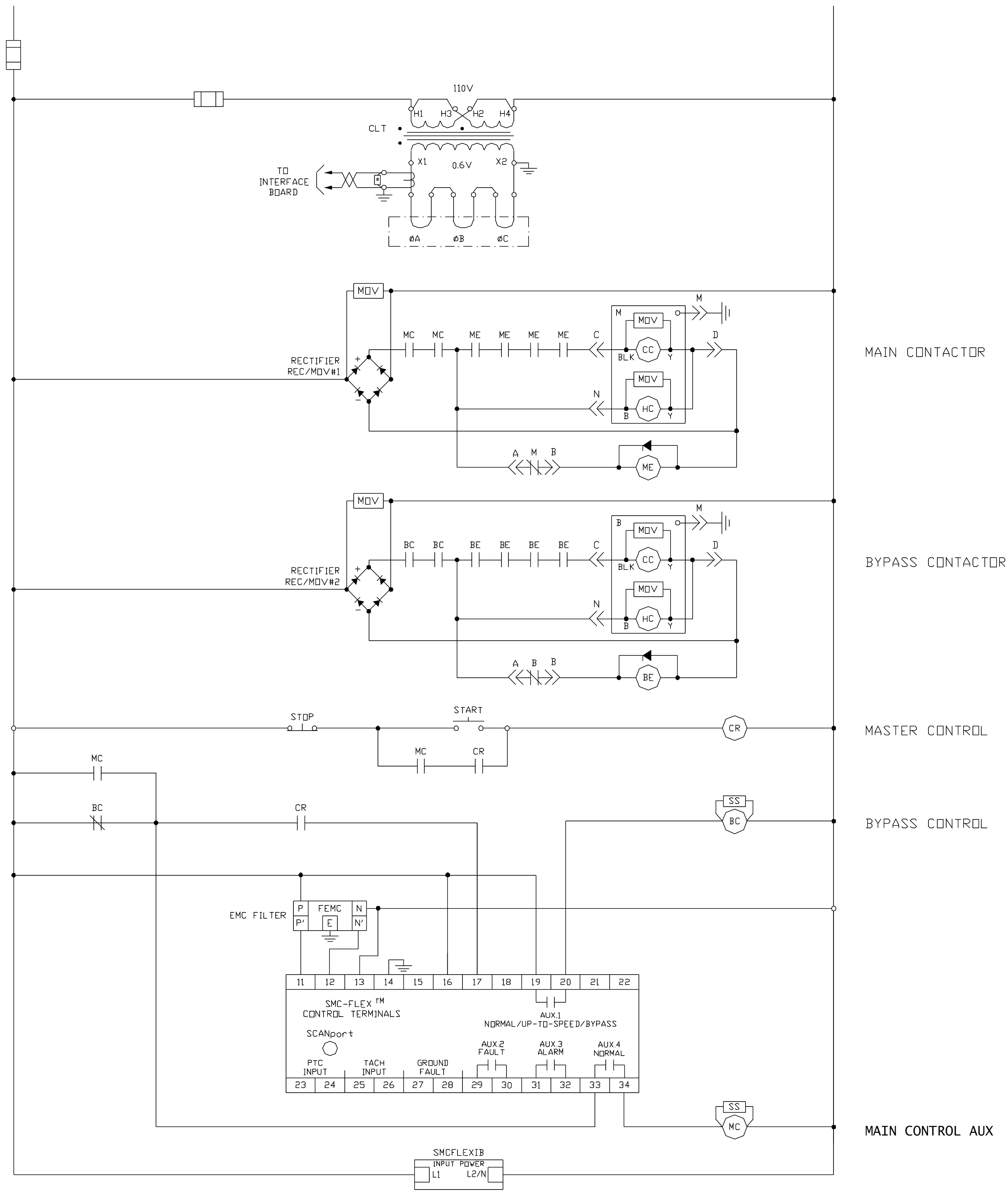

Figure C.1 – Bulletin 1562E Relay Control Circuit • *Without* Stop Control

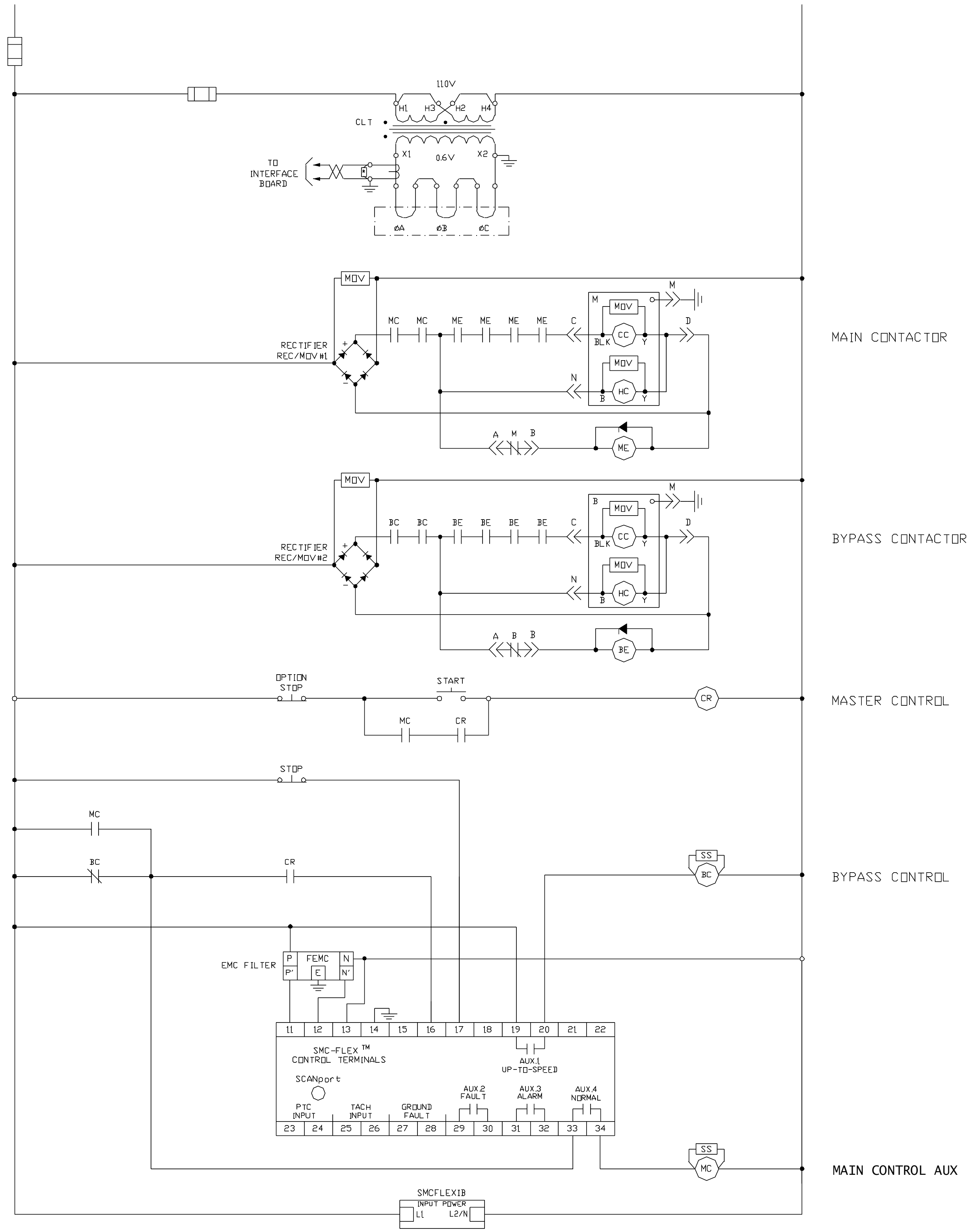

Figure C.2 – Bulletin 1562E Relay Control Circuit • *With* Stop Control

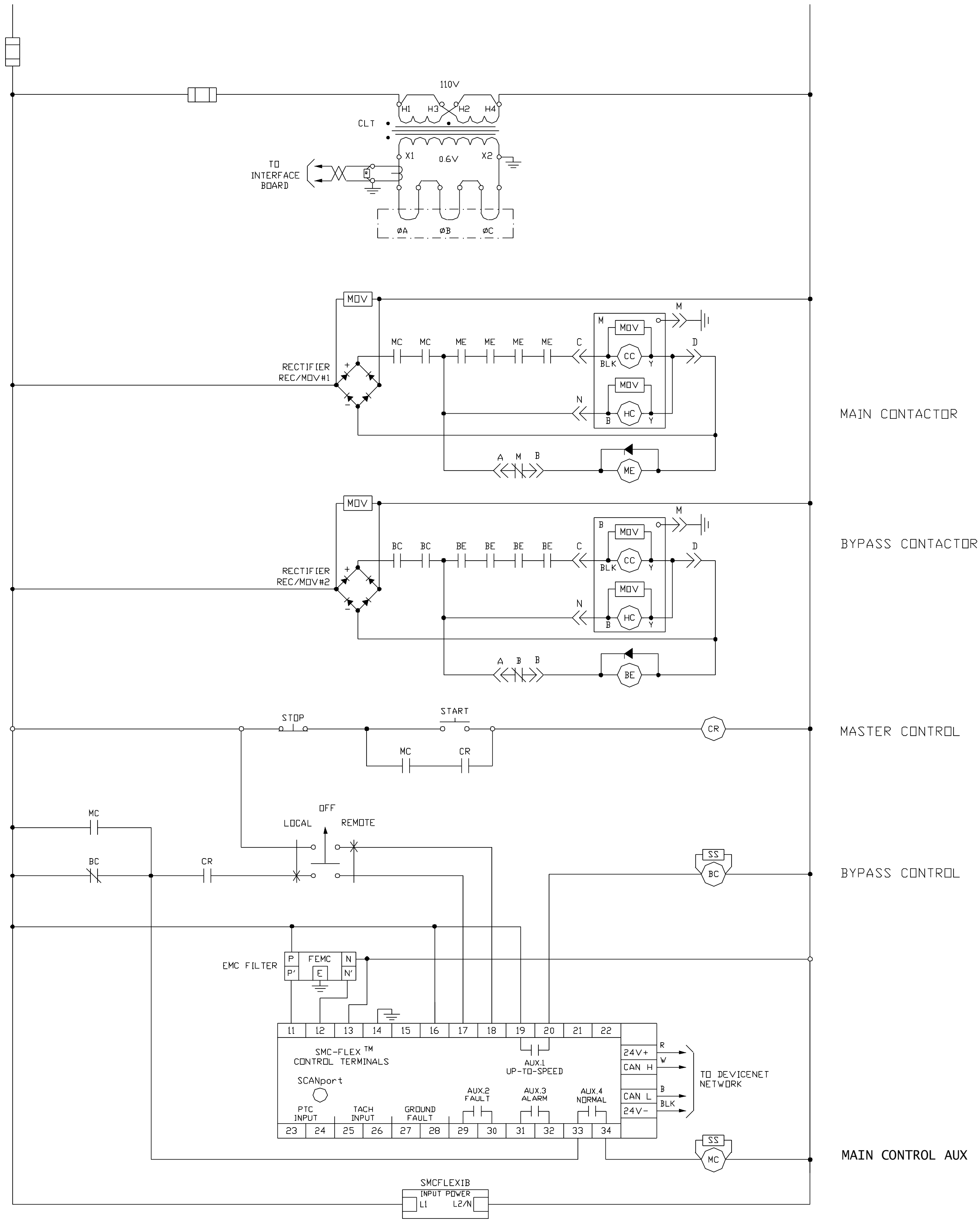

Figure C.3 – Bulletin 1562E Relay Control Circuit • *With* DeviceNet (or DPI) Communication and Optional Local/Off/Remote

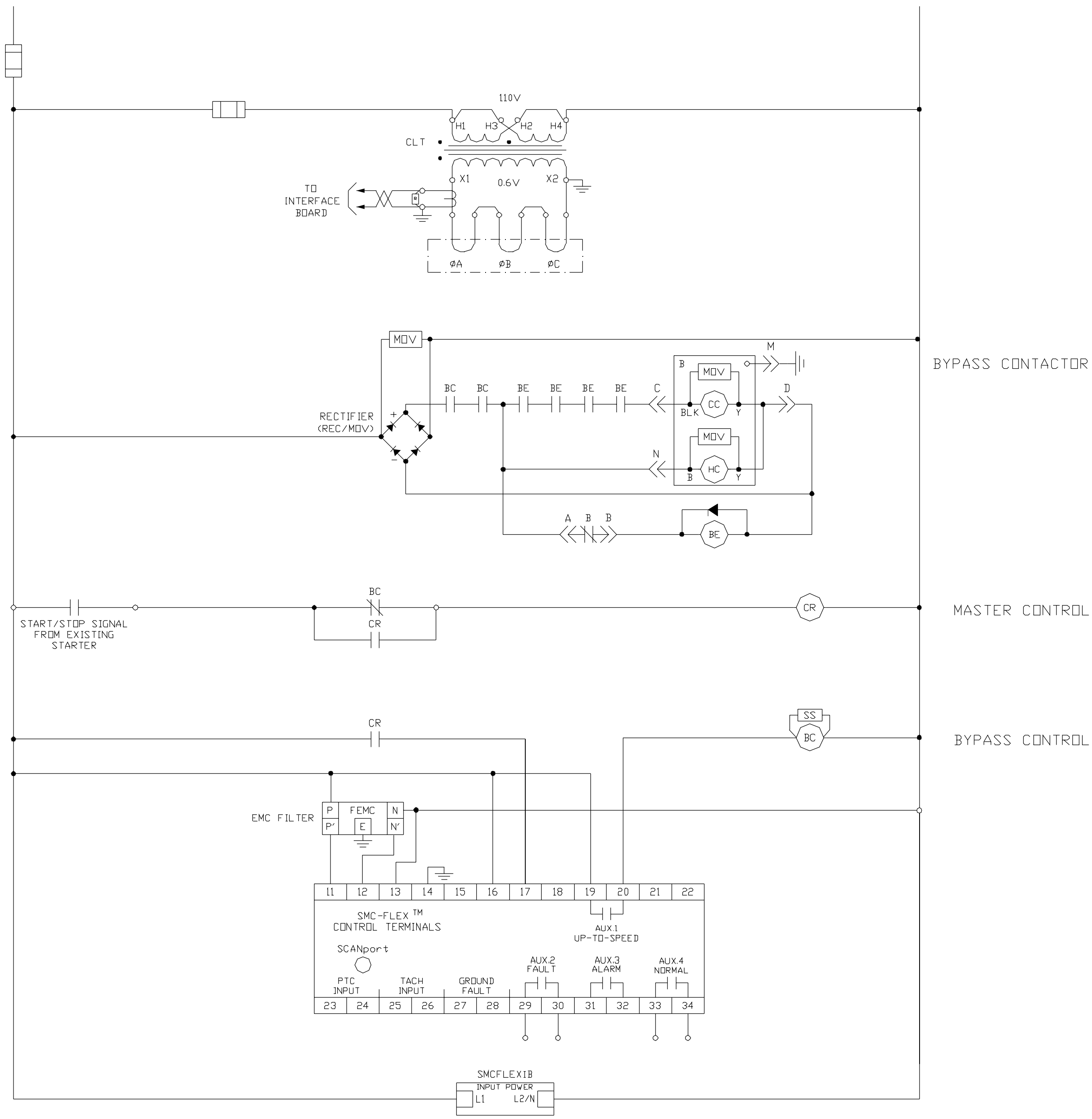

Figure C.4 – Bulletin 1560E Relay Control Circuit • *Without* Stop Control

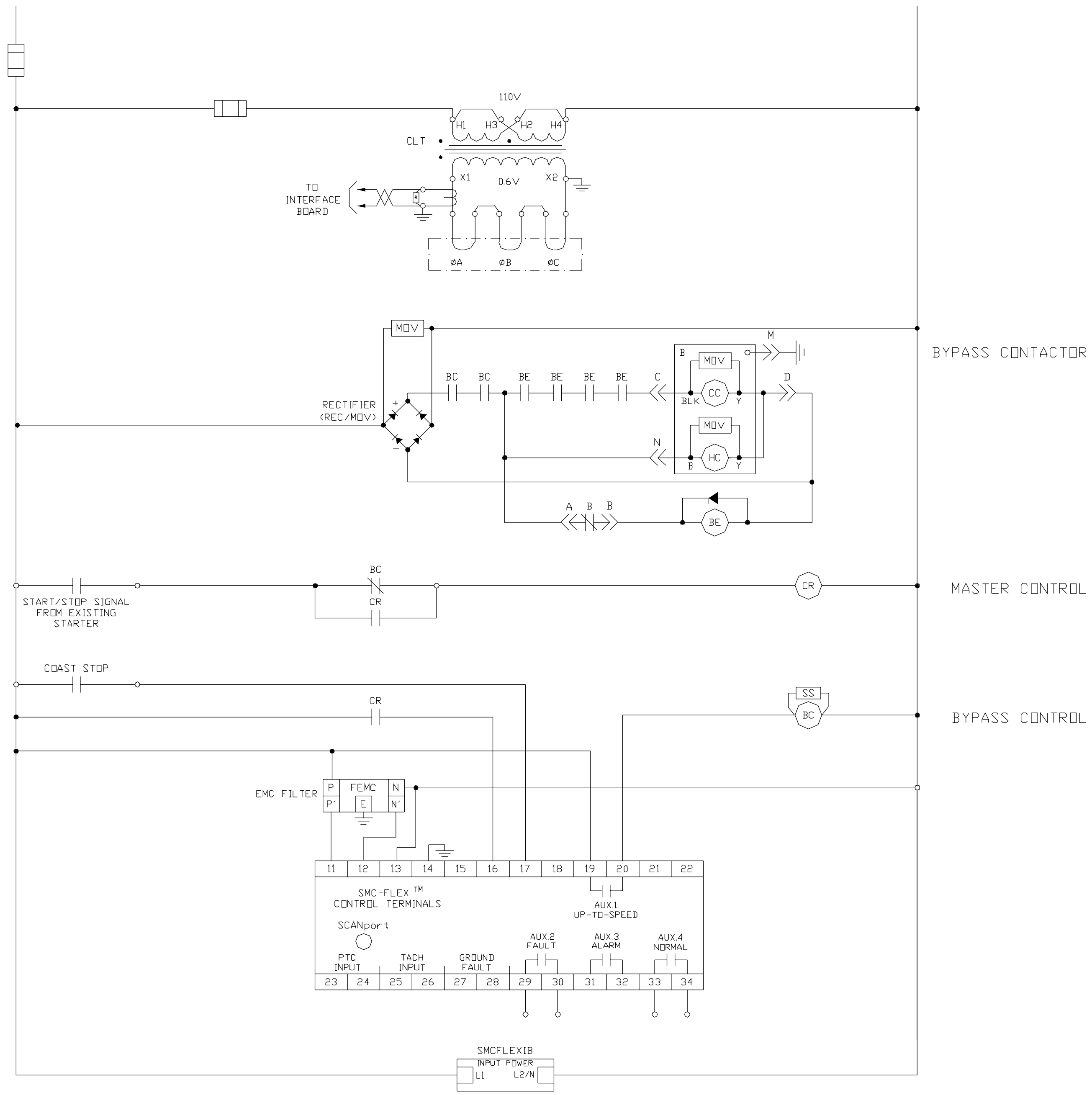

Figure C.5 – Bulletin 1560E Relay Control Circuit • *With* Stop Control

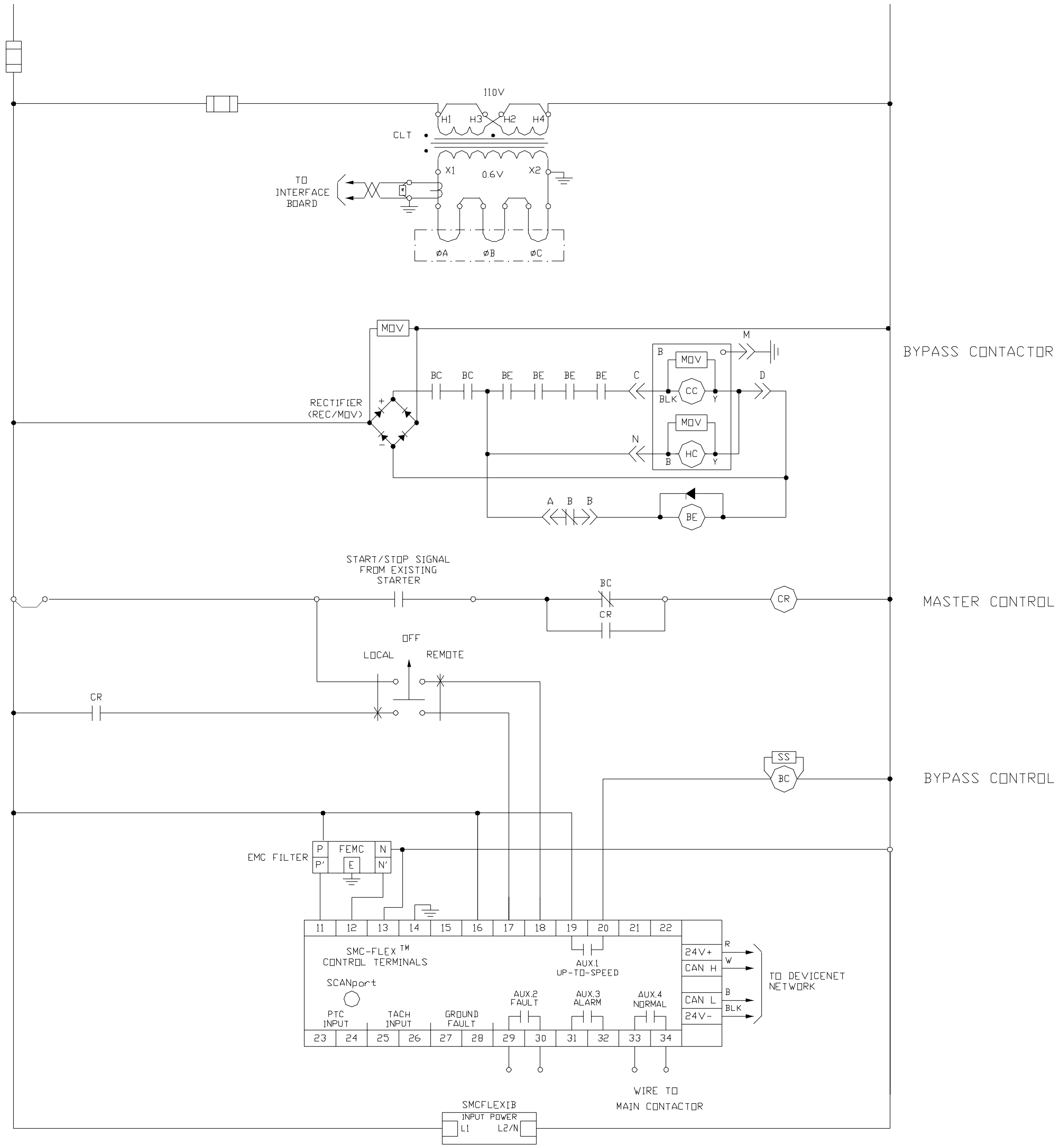

Figure C.6 – Bulletin 1560E Relay Control Circuit • *With* DeviceNet (or DPI) Communication and Optional Local/Off/Remote

Spare Parts

Power Stacks

Table D.1 – Replacement SCRs ❶

SMC Rated Voltage (max.)	Description	Part Number	
		180 Amp	360 Amp
1500	Individual – no matching required (6 per controller)	80156-815-61-R	80156-894-71-R
2500	Individual – no matching required (6 per controller)	80156-893-71-R	80156-894-71-R
4800	Matched set of two (6 sets per controller)	80156-893-72-R	80156-894-72-R
7200	Matched set of three (6 sets per controller)	80156-893-73-R	80156-894-73-R

❶ Due to stringent torquing specifications for 600A power stacks, individual SCRs are not replaceable. It is mandatory that the entire power stack be replaced.

Table D.2 – Complete Power Stacks (3 per controller)

SMC Rated Voltage (max.)	Part Number		
	180 Amp	360 Amp	600 Amp ❶
1500	80187-513-53	80187-513-52	80187-522-51
2500	80187-513-51	80187-513-52	80187-522-51
4800	80187-514-51	80187-514-52	80187-523-51
7200	80187-521-51	80187-521-52	80187-524-51

❶ Due to stringent torquing specifications for 600A power stacks, individual SCRs are not replaceable. It is mandatory that the entire power stack be replaced.

Table D.3 – Snubber Capacitor / Snubber Resistor

Snubber Capacitor	Part Number	
	180/360 Amp	600 Amp
All voltages	80025-812-02-R (0.68 µF)	80025-812-01-R (1.0 µF)

Snubber Resistor ❶	Part Number ❷	
	180/360 Amp	600 Amp
1500/2500/4800 V	80025-588-02-R (20 Ω, 100W)	80025-642-08-R (15 Ω, 225W)
7200	80025-642-09-R (30 Ω, 225W)	80025-642-08-R (15 Ω, 225W)

❶ All parts are ceramic, wirewound, non-inductive winding.

❷ Resistors are series connected for a total of 60 Ω per snubber for 180/360A assemblies and 30 Ω per snubber for 600A assemblies. A controller has one snubber per pair of SCRs (i.e. 3 snubbers for 2500V, 6 snubbers for 4800V, 9 snubbers for 7200V).

Table D.4 – Common Parts

Quantity	Description		Part Number
1 per SCR pair ❶	Sharing resistor 32.5 k? , 225W, two 2.5 k? taps		80025-753-01-R
1 per SCR ❶	Current loop self-powered gate driver board (CLGD)		80190-519-01-R
1 per controller	Voltage Sensing Board (VSB)		81000-199-55-R
1 per controller	Interface Board		80190-440-01-R
(1 per SCR) + 3 ❶	Fiber Optic Cable	2.5 m	80025-549-03-R
1 per controller	Test Power Supply	120 VAC for North America	80187-051-51-R
		Universal	80187-245-51-R
1 per controller	Current loop transformer, 50VA 115/230 : 0.6V		80022-133-01
3 per controller ❷	Current loop cable assembly	5 ft.	80018-246-55
		6 ft.	80018-246-51
		7 ft.	80018-246-52
		8 ft.	80018-246-53
		9 ft.	80018-246-54
1 per controller	Current loop sense CT		80022-163-01

❶ Refer to Table D.1 for an explanation of the number of SCRs per controller, which is voltage dependant.
❷ Different lengths are used for the various configurations. The current loop total length **must** equal 21 ft. for proper operation.

Table D.5 – Accessories

Qty per controller	Description	Part Number
1	Control Module (Standard)	41391-454-01-S1FX
	Control Module (Pump Control)	41391-454-01-B1FX
1	Fan (120 V) ❶	80025-248-01-R
	Fan (240 V) ❶	80025-248-02
	Fuse Extractor	80144-491-02

❶ Optional equipment.

Notes :
1. Reference only.
2. 1503E – For OEM products, refer to OEM-supplied documentation for specific spare parts list. 1560/1562E are Allen-Bradley manufactured starters. Refer to Service Manual for specific spare parts list.
3. For spare parts for starter and contactor components, refer to Documentationon page 1-1.

Accessories

Table E.1 – Accessories

Description	Description/Used With	Catalog Number
HIM	Remote Door Mounted IP66 (Type 4/12) Programmer Only	20-HIM-C3
Communication Modules	Remote I/O	20-COMM-R
	RS 485 (DF-1)	20-COMM-S
	DeviceNet	20-COMM-D
	ControlNet	20-COMM-C
	EtherNet/IP	20-COMM-E
	Profibus®	20-COMM-P
	InterBus	20-COMM-I
	LonWorks	20-COMM-L
	ControlNet (Fiber)	20-COMM-Q
	RS485 HVAC	20-COMM-H

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